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FISH BONES AND FISHING IN FINLAND DURING THE STONE AGE

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ABSTRACT

Burned fish bones are constantly being discovered in the excavations of Stone Age settlements in Finland. This abundance of fish bones, as well as the usual location of the settlements on the shore of lakes or the sea, illustrate the importance of fishing to the Stone Age economy. Added to this, examples of the fishing gear that was used, mostly made of stone, are also occasionally found in Stone Age contexts. Yet, despite the clear importance of fish and fishing in Stone Age Finland, the fish bones themselves have not been studied thoroughly before, although the diversity of the fishing culture at the time could be clarified by such analyses.

I am interested in the everyday food acquisition strategies of the Stone Age forager communities. By studying the surviving bones and tracking the distribution of fish species, I have been able to create a picture of the fishing methods used at the time and the importance of fishing to the community. The availability of fish is highly dependent on the prevailing environmental conditions, and their behaviour directly influenced their potential as a food source.

This empirically driven multidisciplinary study combines data from zooarchaeology, archaeology, ethnography, fisheries biology, environmental studies and, the most importantly, taphonomy. Research on burned bones is rare throughout the international research literature. The essential aspect of this research is to understand the nature of the bone material itself, because with burned bones many different factors can affect the results. Studying the effects of bone survival and the recovery methods used in excavations are thus an integral part of my research.

For this study, I have selected ten sites with concentrated burned fish bone deposits, either on a hearth bottom or in a waste pit. In addition to these site-specific studies, I also address the specific issues of bone burning and excavation methods raised during the study. The archaeological bone fragments were analysed morphologically by comparing them with modern reference bones. However, due to the lack of reference bone material in Finland when I began this study, I started by preparing my own reference collection.

There are several topics can now be more thoroughly and accurately discussed based on this study. According to results provided by the fish bone finds, it is argued that fishing was the most reliable source of daily food in Finland during the Stone Age. Fishing was a mostly opportunistic, low-level daily activity, and all types of fish were considered equally fit for consumption.

Burning is a major taphonomical cause of bone loss. At the same time, it contributes to the preservation of compact skeletal parts. Based solely on the number of bone fragments preserved, no single species can be asserted to have been more important than another, as the bones' taphonomical stability varies between individual species.

Fish bone finds from Finland are generally uniform throughout the Stone Age. All variation in the distribution patterns of fish species can be explained by the location of sites, environmental aspects, and excavation methods. The Stone Age fish bone finds support the theory postulating the use of historically known simple fishing gear. Based on the fish bone data, the fishing methods utilized remained the same throughout the Stone Age. Fishing was probably a year-round activity with some seasonal variations.

1 Introduction

Finland is, and throughout the Holocene has been, a land of the lakes. Along the lake shoreline, where people built their dwellings during the Stone Age, freshwater fishing offers a natural basis for an economy. In addition to the lakes, Finland has always had a long coastline with the Baltic Sea and its early precursors. It is a matter of course that in such an environment people must ate a lot of fish, since fish was easily available almost everywhere.

Burned fish bones (Figure 1) are constantly being discovered in the excavations of the Stone Age settlements in Finland. An abundance of fish bones, as well as the usual location of the settlements on shorelines, show the great importance of fishing in the Stone Age economy. Actual fishing gear such as fish hooks and net weights made of stone are also occasionally found in the Stone Age material. Most of the objects used for fishing were supposedly made of organic materials, and hence have been mostly destroyed. In the acidic soil of Finland, with its low pH (Pärtel et al. 2004), organic material decomposes quickly (e.g., Ukkonen 1993; 1996a; 2004). Fishing gear finds, and fishing have been touched upon by other archaeological studies (e.g., Pälsi 1916; 1920; Äyräpää 1950; Edgren 1967; 1970; 1984; Nuñez 1990; 1999; Rankama 1996; Ukkonen 1996; Schulz H-P 1997; 1998; Huurre 1998; Carpelan 1999; Mökkönen 2001; Kankaanpää 2002; Leskinen 2002). However, actual fishing gear and methods have only been studied quite recently (Minkkinen 1999; 2000; Naskali 2004; Carpelan 2008; Koivisto 2012; Koivisto & Nurminen 2015; Koivisto 2017).

There is extensive historical and ethnographic literature on fishing in Finland (see chapter 4 *Ethnographic background*). These sources, with the addition of Stone Age bone finds, can be used to draw conclusions about fishing as a source of livelihood in the Stone Age.

Fish bones have been severely neglected in osteological analyses of archaeological refuse in Finland. There are few zooarchaeological studies of prehistoric mammals (Ukkonen 1993; 1996a; 2001; 2004; Storå 2000) and birds (Mannermaa 2002; 2003; 2008). Stone Age fish bones were not studied thoroughly before my earlier studies of Late Neolithic fish bones in the 2000s (Nurminen 2004a: 2006; 2007). The reason for this has been an absence of osteologists who are knowledgeable about the fish bone material. The great impediment to producing knowledgeable fish bone osteologists has been the lack of reference bone material. Before my studies, the reference collections of Finnish Museum of Natural History LUOMUS, which is a part of the University of Helsinki, included only a few fish skeletons, one of each of the following species: pike *(Esox lucius)*, perch *(Perca fluviatilis)*, pikeperch *(Sander lucioperca)*, cod *(Gadus morhua)*, bream *(Abramis brama),* and parts of burbot *(Lota lota)* and young salmon *(Salmo salar)*. These bones had been prepared in the early 1960s and had lost many of their parts over the decades. I started my own research by preparing a reference bone collection of Finnish fish species.

Figure 1. Well-preserved burned bones (KM 33923: 9408) from the Neolithic site of Joroinen Kanava Photo: Markku Haverinen, Finnish Heritage Agency

All the fish bones preserved from Stone Age contexts in Finland are burned. Research on burned bones is rare throughout the international research literature. The strong fragmentation of burned bones makes analysis challenging, and unburned bones have largely been available in their place elsewhere in the world. In Finland's acidic soil, organic matter decomposes rapidly, but combustion allows the thick parts of bones to survive. Although burning increases taphonomic processes and reduces the number of bone fragments that are identifiable, without these bones thrown into the fire by humans, no bones would have survived to this day in Finland. These environmental and taphonomic effects make the research of bones in Finland very different compared to many other countries. In addition, the Finnish archaeofaunal fish variety is mostly freshwater species, which is extraordinary compared to the rest of Europe.

This is a book about fish bones and fishing. I have deliberately left out of the mammals, even though mammal bones are found in all the sites where the fish bones have been identified. Over the years I have analysed the numerous burned bone finds from the Stone Age sites, including many mammals bones, and have been especially interested in the soft curves of seal bones, but there was a need to clearly define this research and focus on one topic. Mammals have their own stories.

I am also mainly focusing my studies on my own country Finland. Finland has a strong history of fishing and the natural and environmental conditions differ from even the neighbouring countries. Therefore, there was no wider need to compare Finnish freshwater fishing to the larger-scale marine fishing in the southern neighbourhoods of this research.

When talking about Stone Age communities, I prefer using the word forager instead of hunter-gatherer. The term forager contains a wider range of economical subsistence strategies, and opens minds to consider the real basics of survival methods in the wild instead of focusing on something that seems clearly defined already before the actual dive into the study has even begun.

I have always been interested in nature and animals, long before I ever became interested in archaeology. My reason for seeking to study archaeology in the first place was the great desire to understand people living as a part of wild nature, and to find out how they managed in this cold and distant country in the Stone Age. I have always been more interested in nature-made than man-made. When my co-students talked about their interest in the Iron Age and newer eras, I started my subsidiary subject studies in morphological-ecological zoology. In the second year of my studies, I was introduced to Pirkko Ukkonen, who brought me into her zooarchaeological team and taught me the basics of burned bones. Because there was a need for a fish bone researcher, I decided to start doing research with the fish material with the support of my former professor, the late Ari Siiriäinen. It also felt like one continuum in my family, since my late father had long been a fishmonger and my late grandfather was a fisherman from Lavansaari, a former Finnish island in the Eastern Gulf of Finland now

Figure 2. Veijo Nurminen, at age 7 in 2008, with a reconstruction of a club, a primitive fishing device. Reconstruction made by Risto Järvisalo. Photo: Katariina Nurminen

belonging to Russia. I started my long and over the years bottomless lonely career with burned fish bones in 2002. With this dissertation one circle closes and I finally have a chance to share all my knowledge of the subject with everyone.

1.1 Aims and purposes

Burned fish bones are found in and near the hearths of prehistoric dwellings. The bones are burned during cooking or eating, or then often thrown into the fire. Bones can also be found in waste pits or other large deposits, where they have been specifically collected after the cooking and eating processes.

Fish was likely consumed in large quantities during the Stone Age. The settlements of that time were located mainly on lakeshores and sheltered seashores. Fishing was a subsistence activity that was physically possible for the whole community. The diversity of the fishing culture at the time is made clear by analysing the fish bones. Different fish species were caught by using different fishing gear matched to the different lifestyles of the fish. The more species that are regularly found, the more diverse the fishing methods must have been. The most important aspect is to understand the role of the studied bone material, because with burned bones, so many things affect the results. Bone survival and recovery methods in excavations are an integral part of my research.

The ecology of fish species may also provide an opportunity to learn more about prehistoric environmental conditions. We already know that in the Middle and Late Neolithic period the climate in Finland was warmer than it is today (Seppä & Birks 2001). Studying the distributions of fish in the northern regions may clarify the extent of the warmer climate. The climate of course also affected the living conditions of the human populations.

My multidisciplinary study is a dive into the world of fish bones found at Stone Age sites, and through the lens of the bone a peek into the Stone Age fishing culture in the area of present-day Finland. I am interested in the Stone Age forager communities' everyday food acquisition. In my work I draw a picture about fishing methods, what fishing gear was used, and the importance of fishing to the community.

The study begins with the theoretical questions of forager subsistence, bones, and taphonomy. Next, I review the environmental conditions in Finland during the Stone Age, and Finnish fish species. I then review the ethnographic literature on fishing in the Boreal and Subarctic regions, as well as the archaeological evidence of Stone Age fishing gear and fish bones in Finland. After presenting the materials and methods, next there are two important studies of taphonomical issues affecting the results to consider: the burning and screening of bones during excavation. Then, turn to the osteological analyses of 10 Stone Age sites, most of which have a fish bone pit. After the bone analyses, I present two small case studies, one on burbot *(Lota lota)* finds and one on cyprinid (cyprinidae) species. All of this leads to a discussion and conclusions regarding the main research questions below.

The main research questions of this study are as follows:

- What fish species were fished?
- How do taphonomical processes and excavation methods affect to results?
- What were the fish species´ distribution areas during the Stone Age, and how were they reflected in environmental conditions?
- What kind of ancient fishing gear is suitable for the species found?
- Was fishing seasonal or a year-round activity?

As a conclusion for all these questions, the key question of this study is: What was the importance of fishing in the Stone Age economy and can we discern changes in the role of fishing through time?

1.2 The challenge of a multidisciplinary study

In Finland, only a few osteologists with a science education have previously performed bone analyses of Stone Age sites, and it has been archaeologists who have discussed the results. The results of these fish bone studies have been incomplete due to the problem of a lack of reference material (see *6.2.1 Identification of bones*), something most archaeologists have not known of appreciated. In addition, interpretation problems easily arise at this juncture, as there will inevitably be information gaps between the two disciplines. Can a natural scientist write a report addressing exactly the essential points of interest in archaeology? How does an archaeologist interpret biology-based results without a basic knowledge of biology? I have noticed over the years that the disciplines are in practice quite far from each other, and there can sometimes be considerable mistrust between them. Many times over the years I have heard archaeologist colleagues say, “Interesting, but I do not understand anything about it”, or also “What is the idea and interest of all this stuff?” In archaeology, it is typical to try to find the answer to everything from the perspective of human activities. This could be based on our anthropocentric perspectives or Christianity´s version of human omnipotence, which I do not swallow. Humanistic fields of study often seem to lack a rational relationship with nature and the limitations and opportunities it provides. Similarly, the humanities are not often well understood by natural scientists, and are sometimes even regarded as pseudoscience. Science as based solely on mathematical models is the only “real” science to many. There are many gaps in archaeological knowledge, and explanations can often be made only by reasoning and probabilities. The results are often not based on primarily mathematical facts, and there is usually no absolute certainty about them.

Combining the interpretations of several disciplines can prove more effective. In addition to being able to provide a more detailed justification of arguments, there is much more to explore in the basics of the various disciplines than in limiting research to one small discipline. In one way this may be compared to the popularization of science, where we must be able to explain the facts of science in plain language. How can we do this without undervaluing research in another field? It is not meaningful to write many pages of self-evident facts, although it is partly necessary in multidisciplinary research. It is often difficult to find a compromise.

Zoology is indeed a strange discipline for many archaeologists. As the first archaeologist studying zoology as a minor subject in Finland, it has been a great advantage to be able to draw conclusions from the knowledge of both disciplines. This is particularly evident in the study of fish bones compared to, for example, mammalian studies, since the prevalence of fish is highly dependent on the prevailing environmental conditions and their behaviour directly influences the potential of their being caught. This study combines data from zooarchaeology, archaeology, ethnography, fisheries biology, and environmental studies, and - most importantly - taphonomy.

2 Theoretical background

This empirically driven multidisciplinary study of Stone Age fish bones and fishing draws on many different disciplines: osteology, archaeology, ethnology, fisheries biology, and environmental studies. The study combines the humanities and sciences, which is basically easy when using common sense, but explaining it, and especially integrating the fields for broader public consumption, has proven surprisingly challenging.

Finland's nature, with its abundant inland waters and long coastline on the Baltic Sea, suggests in itself that fishing has been widely practiced since the earliest forager cultures. The rich fishing tradition of historical times indicates the same (see 4.2 *Historical knowledge about ancient fishing methods in Finland*); there is no reason to doubt that people have fished long before the publication of ethnographic studies. To find the truth of this question, we need archaeological finds. In addition to knowing that they were fishing, it is also important to know what was fished (Butzer 1972). Only by tracking fish species can we get real answers that will help us understand fishing in the Stone Age.

The primary material of this study is burned fish bones found in archaeological excavations. Burned fish bones are direct human waste, therefore they can tell us, directly or indirectly, whether our ancestors were fishers. Burned bones are not only organic perishable material; they are also artefacts. They can be identified and quantified, but processing the information they provide, such as that on Stone Age subsistence, requires a broad view of practical everyday issues. There is no direct information about Stone Age life, and we can never know for sure what that life was really like; we can only appraise probabilities (Binford 1972; Siiriäinen 1993). In order to study Stone Age fishing, closely linked as it must have been to daily life, we need to understand not only human behaviour, but also the behaviour of the fish as well as the encompassing environmental context (Butzer 1972). In addition to these factors, interpretations are also influenced by issues related to bone preservation, discovery, and recovery.

We must always remember, when making interpretations based on archaeological materials, that the discovery of artefacts is often coincidental as well as largely incomplete compared to the artefacts that people actually left behind in their time. Based on the objects found, we can claim with a high probability that the object in question was of some importance to its user (Binford 1972). However, most of the artefacts will never be found. Therefore, it cannot be argued with certainty that the absence of an artefact means that it did not exist; we can speak only of probabilities.

2.2 The life and diet of fishing foragers

Fishing is probably as old as humankind. It is primary production, a form of gathering, one of the simplest forms of economy. In the foraging lifestyle, every necessary object is taken that can be eaten or used in any other way (von Brandt 1984).

Forager populations are a part of an ecosystem; their economies depend upon the ecological patterns of the available food resources (Brothwell & Higgs 1969). In addition to the use of elaborate fishing gear, fishing in ancient forager cultures was strongly based on people´s fundamental understanding of fish behaviour. By living as a part of nature and patiently observing the environment, human can acquire the skills and knowledge to outwit the fish and catch it with even simple gear. These skills are generally unattainable to modern humans, mainly because the knowledge of fish behaviour has fallen by the wayside (von Brandt 1984, see also Binford 2001).

Human activity is affected by environmental and climatic conditions (Brothwell & Higgs 1969), but the world has changed significantly from the Stone Age to the present. To understand human life in the Stone Age, we must dive into nature (Binford 2001), which may not be easy for the modern inhabitants of an industrialized country. Archaeological knowledge is primarily embodied in artefacts and often completely tied to their chance of being found and the methods of data collection. One can make a study of historical foragers to try and understand the ancient lifestyle (Binford 1972). However, even the ethnographic record requires interpretation, because practically all historical foragers have more advanced technology compared to their ancestors in the Stone Age, and therefore ancient and historical forager cultures are not fully comparable (Binford 2001, Marlowe 2005). Many practical solutions can remain in place for thousands of years, and by exploring historical ways of life we can also draw some conclusions about ancient ways (Binford 2001).

On a global scale, the forager diet is variable. This variation is not as simple as some foragers eat mostly plants, or some eat mostly meat (Kelly 2013), as the habitat plays a major role in nutrition strategies. Forager diets are known to be systemically related to the environment (Kelly 2013). In warmer climates, plants are the basis of nutrition. Aquatic resources, such as fish, tend to be used more in cold than in warm climates, in environments where there are insufficient edible plant foods year round (Marlowe 2005; Kelly 2013); for example, because of a cold winter climate and the resulting overwintering of plants. In many cultures in the north, fishing plays a more important role in nutrition than hunting (Marlowe 2005; Kelly 2013).

What, then, are the benefits of fishing over hunting in the north? Hunting in cold environments requires movement over large areas, as mammals have broad territories. Fish, on the other hand, can easily be obtained with less effort (Kelly 2013). Various theoretical optimal-foraging models have been developed for interpreting foragers´ dietary intake and the rational use of various raw materials, of which the diet-breadth model (DBM) is the most widely used. DBM calculates the benefit of the resource based on the time it takes to find, collect, and process the food, along with the nutritional value of the resource in calories. The result is a figure, the overall foraging return rate. The higher this number, the more profitable the resource (Kelly 2013). Finding, collecting and processing the resource depends on both environmental and cultural factors. In my opinion, calculating the overall foraging return rates in the Finland's Stone Age life would require extensive empirical testing, reconstructing ancient hunting and fishing methods. However, the results would still be uncertain because we are probably unable to consider all the cultural and environmental features of the Stone Age (see also Matiskainen 1989; Binford 2001). We must also remember that diet is defined by more than just the most profitable option.

It has been shown that foragers consuming fish as their main diet have reduced mobility compared to people whose main diet is plants or terrestrial mammals (Marlowe 2005). However, this theory originates with indigenous peoples on the West Coast of North America, who mainly subsist on anadromous fish (Marlowe 2005). Despite this, it may just as well apply to people eating mainly freshwater fish, especially since they are easier to catch and often for longer periods, as they do not disappear far into the sea for months at a time. Sedentary living makes life more stable, and energy can be redirected to other activities instead of constantly following the food resource. It is also shown that food storage dramatically increases among foragers in colder climates (Kelly 2013), which most likely suggests more permanent than short-duration seasonal dwellings.

In Finland, in addition to seasonal variations, the local weather and the environment can be subject to many other fluctuations. The winters may be mild one year and severe the next, and the summers may be rainy and chilly or scorching dry and hot (see also Kelly 2013). The behaviour of animals varies according to such circumstances, and therefore some mammals may remain inaccessible for some years. On the other hand, freshwater fish living in a lake go nowhere during short-term annual weather fluctuations. At most, the spawning grounds may vary slightly, however, it is most likely not difficult for a person with a good understanding of nature to find them again. The situation may be different for broader climate and environmental changes (Manninen 2014), as the temperature and eutrophication of the waters may also change, which may result in a change in the fish species. In this case, although changes in the environment will certainly change human activities (Manninen 2014), people living in the wild are still most likely to rapidly adapt their knowledge to the behaviour of new fish species. Not necessarily in a couple of years, and perhaps not even in one generation, but with the highest probability in the next generations. This can be seen, for example, from current technological advances and the development of skills in using modern technology, when comparing young people with their parents. Today young people are generally more advanced in their technological skills than their parents; the acceleration in present-day knowledge transfer and the rapid uptake of new knowledge are evident between the two generations. As discussed, a major part of human intelligence is the ability to adapt (Tooby & DeVore 1987).

2.3 Taphonomy, a zooarchaeological challenge

Zooarchaeology, a part of environmental archaeology studies, is the study of the way past humans have interacted with animals. Zooarchaeology studies non-human animal remains related to ancient people; specifically, this involves the identification of animal species from archaeological contexts.

The main data source in zooarchaeology, bones, is an organic material whose preservation or destruction is affected by many natural factors. These include:

- the properties of the bones themselves (e.g., fat content and fragility),
- the physio-chemical parameters of the soil (pH, aeriation, abrasive effect),
- climatic factors (temperature and humidity, freeze/thaw effects).

Importantly, animal bone assemblages are also formed by past (e.g., dismemberment, burning) and present (methods of survey and recovery) human actions (Bartosiewicz 2001).

Therefore, taphonomy is the basis of all zooarchaeological studies, the fundamental theoretical framework (Boethius 2018), the importance of which can never be underestimated. Taphonomy is the study of transition; the processes that lead human and animal remains to fossilization, and the stages of transformation of remains through the action of environmental factors (Efremov 1940). In zooarchaeology, it begins with the environment's effect on the animal's physiology, as that would in turn effect both its survivable physical structure and the likelihood of it being hunted, goes to the human decision of killing an animal, going through the slaughtering and cooking, discarding and deposition, and leading through to discovery until the research process is completed (e.g., Lyman 1994). All these steps cause selective loss of information.

In zooarchaeological studies, identifying which animal taxa were eaten by our ancestors, and how much of each animal taxon was eaten, is a taphonomic question par excellence. Taphonomy thus presents a research question that can be briefly phrased as "What are these bones doing in this site?" (Lyman 1994). When burned bones are the source of study, as in this thesis, taphonomy rises to the most important methodological position. Bone loss due to burning distorts research results if its importance is ignored. In addition, in the case of burned and small fish bones, excavation techniques also play an important role in how much bone material is recovered at all. The advantage of the burned fish bones found in the archaeological contexts is that we can say with certainty that they are remnants of human activity.

In Finland, zooarchaeology is still in its infancy. The information provided by animal bones in human contexts has not always been fully understood. Finnish archaeology was long based on the typological classification of objects (e.g., Siiriäinen 1993). Ceramics and stone tools were among the most important research topics of the 20th century for the Stone Age researcher (see 5.1 *Archaeological evidence of fishing*). Of the natural sciences, geology has long been involved in archaeological research. It is only in the last couple of decades that archaeology has generally broadened its scope to include other disciplines than geology to help explain open questions, which is largely due to the overall development of scientific methods. Nowadays in the 21st century, the natural sciences have taken over archaeology and archaeological research almost invariably employs natural science methods. Unfortunately, zooarchaeology is still in the hands of only a few dedicated researchers in Finland, and osteology as a subject cannot be studied anywhere. A major obstacle to the development of zooarchaeology is evidently the fact that bones tend to be dissolved in the typically acidic soils of Finland. However, they may be preserved when burned (e.g., Ukkonen 1993; 1996a; 2004). People commonly consider burned bones difficult to study and identify (e.g., Ukkonen 1996a; 2004) because of their high degree of fragmentation. In addition, the information that can be garnered from burned bone material is much more limited. Only the skeletal element can often be identified, or in better preserved and larger fragments also family or species.

Since the reliability of the information from burned fish bones is unclear, mainly due to taphonomic problems, I have included two specific empirical tests in this study dealing with the research questions: a bone burning experiment and a screening test. The bone burning experiment examines how much of the bone material is destroyed in the cooking processes before being discarded as waste and buried. In the screening test, I studied how the use of different sized sifting screens affects the recorded number of bones and our knowledge of fish species distribution. The use of these methods, and an understanding of their effects on taxonomic identification, are essential for the reliable interpretation of results.

3 Environmental background

During the latest glaciation, called the Weichselian, Finland was covered with thick ice up to a depth of more than three kilometres (Tikkanen & Oksanen 2002; Tikkanen 2006a). In the end of the Weichselian period, ca. 11400 – 9500 BCE, the temperature of the climate rose several degrees, causing the ice to melt rapidly. Finland was freed from the ice almost completely during the Lake Ancylus stage, ca. 8800-7200 BCE. (Lundqvist 1986; Donner 1995; Hyvärinen 1997; Eronen et al. 2001; Saarnisto 2003). At the time of Lake Ancylus people had already entered Finland (Takala 2004; Pesonen et al. 2014; Tallavaara et al. 2014), and the earliest evidence of fishing, the famous Antrea fishing net (see more in 5.1. *Archaeological evidence of fishing*), was being used there and eventually fell to the bottom of the water (Pälsi 1914; 1920; Carpelan 2008).

The Danish Straits broke out ca. 7200 BCE (Miettinen 2002), and the freshwater Ancylus Lake changed into the brackish Littorina Sea, having a higher water salinity than the current Baltic Sea (Rosenberg & Rosenberg 1972, Gustafsson & Westman 2002). The Finnish Stone Age is dated to the Ancylus Lake and Littorina Sea periods, starting from the Mesolithic (ca. 8850-5200 BCE) to the Neolithic (ca. 5200-1900/1700 BCE) (Halinen 2015).

3.1 Formation of land and waters

During and after the glacial unloading, the water level was much higher than it is today, and some of present-day Finland was still under water. The heavy ice had depressed the earth´s crust, and the following isostatic post-glacial rebound, which continues in Finland even today, changed the environment over the centuries through continuing shore displacement (Saarnisto 1971; Tikkanen & Oksanen 2002; Tikkanen 2006a; Kakkuri 2012; Seppä et al. 2012).

The post-glacial differential uplift had a major impact on the development and configuration of the Littorina Sea, as well as the lakes and rivers in the region. The waterways were transformed - new lakes and rivers were born while old ones dried up. As a result of land uplift, the lake areas were isolated from the sea (Saarnisto 1971; Tikkanen 2006b; Seppä et al. 2012). The predominant phase in the isolation of the lakes was the Ancylus regression, at the end of which almost the whole central Lake District was isolated (Saarnisto 1971; 2000). The isolation of the greater lakes, Lake Saimaa and Lake Päijänne, proceeded from south to north (Saarnisto 2000). After this isolation, tilting and transgressions caused the formation of new outlets in the lakes, as occurred in Lake Saimaa, the largest lake in Finland (Saarnisto 1971; Tikkanen 2006b; Seppä et al. 2012), with the formation of the present outflow channel, the River Vuoksi ca. 3900 BCE (e.g., Saarnisto 1970; Halinen & Mökkönen 2009; Halinen 2015). Lake Saimaa and many other larger lakes in eastern and central Finland first drained to the northwest into the Gulf of Bothnia, until the land uplift led to the formation of the current southern outlets (Saarnisto 1971; Tikkanen 2002). The majority of the changes in outflow channels occurred between 8500 – 4500 BP (Tikkanen 2002; 2006b), during the Stone Age. Nowadays Finland has 187 888 lakes (Kuusisto 2005).

In the western coastal areas, new land was constantly exposed from underwater. Land uplift was, and still is, the fastest in Ostrobothnia (Saarnisto 1970; Kakkuri 2012; Seppä et al. 2012; Ojala et al. 2013), while it became radially slower towards south-eastern and southern Finland (Seppä et al. 2012). At the Gulf of Finland in the south, the water level remained more stable. In south-eastern Finland, the water level even rose during the Littorina transgression between 7400-7100 calBP (ca. 5400-5100 BCE) and 6500-6300 calBP (ca. 3500-3300 BCE), after which the ground began to rise again (Miettinen 2002).

As a result of the land uplift, shoreline locations have varied over the centuries and millennia. The highest shoreline at a particular point is the uppermost level to which the waters of the Baltic basin have reached. Areas above the highest shore of all the Baltic Sea stages are called supra-aquatic, while areas that were covered by Baltic waters in the past are called subaquatic (Eronen 1992; Saarnisto 2000; Tikkanen & Oksanen 2002; Tikkanen 2006a). More than half, about 62%, of the surface area of Finland has been under-water during at least some of the Baltic Sea stages (Tikkanen & Oksanen 2002). Eastern and northern Finland are largely supra-aquatic, while southern and western Finland are subaquatic (Eronen 1992; Tikkanen & Oksanen 2002; Tikkanen 2006a).

During the Stone Age, many inland water basins, such as the Great Lake of Central Finland, which was formed by the Ancient Lake Saimaa and the Ancient Lake Päijänne, had much broader expanses of open water than today (Tikkanen 2002; 2006b). The land right above the shoreline when the water was at its highest is called the maximum terrace, a term that is also important for archaeological research because settlement sites were mainly located on the shoreline. In addition to the maximum terrace, an ancient shoreline area can have several other terraces, depending on the different water levels at different times. This applies to both inland and marine areas. Shore displacement rate is a widely-used method to date sites in archaeological research.

3.2 Climate conditions in Finland during the Stone Age

During most of the Stone Age the temperature was higher in Finland than it is today, as it was elsewhere in the North Atlantic and Fennoscandia (Seppä & Birks 2001). Some short-term temperature fluctuations took place during that time, for instance the 8200 calBP (ca. 6200 BCE) cold event (e.g., Allen & al. 2007; Seppä & al. 2009a; Manninen 2014). The centuries between ca. 8000-4800 calBP (ca. 6000-2800 BCE) are called The Holocene Thermal Maximum (HTM) (Seppä & al. 2009a), when the mean temperature was 1.5 - 2 C° degrees warmer than today (e.g., Heikkilä & Seppä 2003; Enghoff & al. 2007), and the air was dry (e.g., Hammarlund & al. 2003; Antonsson & al. 2008; Seppä & al. 2009a) with lower precipitation (Seppä & Birks 2001). In Lapland, the mean July temperatures were even higher, ca. 2.5 C° warmer than today (Kultti 2004). In this kind of a relatively dry climate, the lake water levels would have been low (Hammarlund & al. 2003, Korhola & al. 2005). During the HTM, both summers and winters would have been warmer (Heikkilä & Seppä 2003) and the snow-free time in winter longer, but in northernmost Lapland winters would still have been cold (Allen & al. 2007). At the end of the HTM towards the end of the Stone Age, the temperature started dropping, eventually falling to its coolest about 2000-500 BCE (Kultti 2004). The precipitation increased, and the climate become moister (Seppä & Birks 2001) and the lake water levels also rose as the climate cooled down (Korhola & al. 2005).

The vegetation also changed during the Stone Age. At first after the retreat of ice, when the climate was cool, the vegetation was dominated by mixed shrub and birch (*Betula*). Early in the Mesolithic Stone Age, arboreal vegetation increased with the dominance of pine (*Pinus*). The mild climate of the HTM brought along alder (*Alnus*) and deciduous trees, such as elm (*Ulmus*), oak (*Quercus*), linden (*Tilia*), and hazel (*Corylus*). Deciduous trees did not spread up into Lapland (Donner 1978; 1995). Spruce (*Picea*) became common only during the Neolithic Stone Age (Donner 1978; 1995; Simola 2003; Seppä et al. 2009b) and spread throughout Finland over a couple of thousand years (Simola 2003; Seppä et al. 2009b). Towards the end of the Stone Age deciduous trees declined as the climate cooled off (Donner 1978; 1995; Simola 2003).

3.3 Fish species in Finland

In this chapter, I will provide a brief summary of the fish species appearing in Finland today. I consider this important because the Finnish fish species are somewhat different from the European variety, which have been much studied in the international history of zooarchaeology. It is important to understand the habitat requirements of different fish, as their lifestyles affect the methods used to catch them (e.g., Morales Muñiz 2007). Fishes spawn in coastal waters or rivers, generally in larger shoals, at which time they are particularly easy to catch with simple fishing gear. At other times, some fish may live deep in a lake or sea and are out of reach of fishermen.

The Finnish fish used for food are mainly of the freshwater varieties. Finland has thousands of lakes and the only direct coastal contact with the sea is the Baltic Sea, a habitat of both marine and freshwater fish. In addition to the Baltic Sea, there is a connection from Finland through northern Norway to the Arctic Ocean, through the rivers of northernmost Lapland. The Baltic Sea, along with the Black Sea, is the world´s largest brackish water basin and the surface water salinity decreases towards the north, the Gulf of Bothnia and the Gulf of Finland. The salt content in Finnish coastal waters is today at most 6-7 ‰, a little less than one-fifth of the salinity of the oceans. At the end of the Gulf of Finland salinity decreases to 4 ‰, and at the end of the Gulf of Bothnia even to 2 ‰ (e.g., Lehtonen & Dahlström 2003; Lehtonen 2003; Herlemann & al. 2011). During the Littorina Sea period in the Stone Age, the surface salinity in the inner parts of the Gulf of Finland and Gulf of Bothnia was probably at its highest, more than twice the present rate (Gustafsson & Westman 2002). The habitats of the fish are likely to have slightly deviated during the Stone Age due to the warmer climate and higher salt content in the Littorina Sea.

A relatively small number of fish species live in Finland. There are 71 species of fish permanently living in our country today, some of which have been transplanted by humans. This number includes all fish, even the smallest ones not fished for food. Many of those small fish live in the marine brackish environments and are not found in inland waters. The number of freshwater fish is 46 species, of which 43 species also live in brackish water (Yrjölä et al. 2015).

The assumptions about the distribution and spread of fish species in Finland are mainly based on environmental changes and the different developmental stages of the Baltic Sea after the end of the latest glaciation, and the ecological requirements of different fish species. It is likely that all the freshwater fish species currently living in Finland were here already during the human settlement period in the Stone Age. The current Finnish freshwater fish assortment was probably formed during the Ancylus Lake period as the Middle European rivers flowed into the Ancylus Lake, and was similar to the present-day by the end of the period about 9,000 years ago. After the Ancylus Lake stage, there were few freshwater fish left in the Littorina Sea because of the previously mentioned higher salinity of the water. In addition to marine fish, the possible remaining freshwater species on the Littorina Sea - according to the two reference books - were whitefish *(Coregonus lavaretus)*, ide *(Leuciscus idus)* and vimba bream *(Vimba vimba)*. (Koli 2002; Yrjölä et al. 2015). As salt levels decreased, freshwater fish would have been able to spread back into coastal waters. The eventual appearance of all existing marine fish in the Baltic Sea can be explained by their spread from the North Sea through the Danish Straits during the Littorina Sea period (Koli 2002).

Here I will briefly introduce the species that have either been found in osteological analyses of prehistoric sites or could be expected to be found, and the simple fishing methods appropriate to these species. Due to the preservation problems of Finnish soils (e.g., Ukkonen 1993; 1996a; 2004), I have left out of all the small species of fish, including Baltic herring (*Clupea harengus membras, silakka* in Finnish) and sprat (*Sprattus sprattus, kilohaili* in Finnish) living in the Baltic Sea, and freshwater vendace (*Coregonus albula, muikku* in Finnish), which are however all very delicious and commonly used as food. Such small fish bones are unfortunately unlikely to be preserved in a recognizable condition, especially when burned. Also, none of these three species have been found in Stone Age contexts. Actual marine fish are almost absent in the Finnish coastal sites. Burning, on the other hand, can be a key to bone preservation under the local acidic soil circumstances.

The descriptions of fish species in this context are based mostly on two comprehensive and valued books of fish, both named *Suomen kalat* (Finnish fish). The earlier book (Koli 2002) was written by Lauri Koli and was first published in 1990. I have used the third edition printed in 2002. The later book (Yrjölä et al. 2015) was made by Sakke Yrjölä, Hannu Lehtonen and Kari Nyberg, and was published in 2015. Both books are written in Finnish. In addition to the information on habitats and lifestyles, the spawning season information is important, because during that time it easier to catch fish as they flock to the shoreline. It is possible that in the warmer climates of the Stone Age, the spring spawning of the fish may have been earlier than today as described in modern works.

For more on fishing methods, see the chapter 4.2 *Historical knowledge about ancient fishing methods in Finland.*

3.3.1 Brackish water species

Descriptions are based on Koli 2002 and Yrjölä et al. 2015:

COD (*Gadus morhua, turska* in Finnish) probably arrived in the Littorina Sea about 8,000 years ago. Cod lives throughout the entire Baltic Sea mostly in deep, cold waters. The spawning season is in the spring and early summer, but the Finnish coastal waters are not nowadays salty enough for cod to spawn. Cods living in Finnish waters spawn further south in the Baltic Sea. Today, recreational fishermen can catch cod on the coast of Finland, e.g., with nets or hooks, or by ice fishing with hook and line.

FLOUNDER (*Platichthys flesus, kampela* in Finnish) and TURBOT (*Scophthalmus maximus, piikkikampela* in Finnish) are flat groundling fish, the first living in the coastal waters of Finland and the latter up to the south of the Gulf of Bothnia. Both can be caught with gillnets or hooks and lines in shallow coastal waters, especially during the spawning season in May-June. Flounder cannot spawn in water lower than 5-6 ‰ salinity, and turbot need at least 6-7 ‰ to spawn (see also Lehtonen H. 2007), so in many Finnish coastal areas spawning is not currently possible.

EEL (*Anguilla anguilla, ankerias* in Finnish) is a snakelike catadromous fish that spawns in the Sargasso Sea in the Atlantic. Eel are quite rare today in Finland, but sometimes appear in the coastal areas and also in the rivers and lakes almost everywhere up to southern Lapland. The present-day eel has become endangered. Eel is a groundling fish and active at night time. Hooks and lines as well as weirs are good fishing gear for eels, and night-time torch fishing can also sometimes bring the eel to catch.

SALMON (*Salmo salar, lohi* in Finnish) is an anadromous fish; breeding sites are in flowing freshwaters and growing areas in the sea. Salmon live throughout the Baltic Sea, and their eggs need plenty of oxygen to survive. After spending the winter in the Baltic, the first salmon arrive in the northern rivers in late spring, just after the ice leaves and when the river floods (e.g., Itkonen 1948; Vilkuna 1974). In northernmost Lapland, salmon arrive directly into the rivers from the Arctic Ocean. Salmon can be caught at this flooding time from the shoreline with seines and light weirs, as well as during the spawning time in September-October with nets and leisters. In summer salmon swim deeper in the river, and fishing often requires larger-scale techniques, such as larger weirs or dams.

In addition, LANDLOCKED SALMON (*Salmo salar sebago, järvilohi* in Finnish), the ecological salmon breed of inland waters, appears presently in the water system of Vuoksi in South-Eastern Finland. Their origin may be in the time of the Yoldia Sea, when the fish were imprisoned in inland waters as a result of the rise of land. During that time, the waters of Lake Saimaa, to which the Vuoksi water system is connected, flowed into the Gulf of Bothnia (Koljonen 2008). The current eastern flow, from the River Vuoksi to Lake Ladoga appeared ca. 3900 BCE (e.g., Saarnisto 1970; Halinen & Mökkönen 2009; Halinen 2015) after the land had risen enough in Suomenselkä in the west.

Out of CYPRINIDS (Cyprinidae, *särkikalat* in Finnish), VIMBA BREAM (*Vimba vimba, vimpa* in Finnish) must be mentioned here. Vimba bream lives in the coastal waters of Finland, except for the northern parts of the Gulf of Bothnia, and spawns in rivers in May-June. It may spend the whole summer in rivers, where it can be caught with hooks and lines, traps, or long-handled landing nets, until going back to the sea in autumn. In the sea, vimba bream is caught with nets. Vimba bream does not appear in lakes in Finland.

BULLROUT (*Myoxocephalus scorpius, isosimppu* in Finnish) and FOUR-HORNED SCULPIN (*Myoxocephalus quadricornis, härkäsimppu* in Finnish) are rarely fished but are tasty fish food. These strange looking fish belong to the family Cottidae of Scorpaeniformes and spawn in wintertime, from December to February. They are most likely to be caught by winter nets or by ice fishing with a hook and line through a hole in the ice. Bullrout only lives in the Baltic Sea, but four-horned sculpin also appears in the Saimaa water system area, having been imprisoned by the rise of land as were the landlocked salmon (see also Koli 1985).

3.3.2 Freshwater species

Descriptions are based on Koli 2002 and Yrjölä et al. 2015:

Freshwater fish species live in inland lakes and rivers. Many freshwater fish also manage in brackish water with low salinity, like the Finnish coastal areas of the Baltic Sea. Unlike marine fish, inland fish often move in much smaller areas and the stocks are often quite local.

There are three inland fish in the family of PERCIDS (Percidae, *ahvenkalat* in Finnish) in Finland: PERCH (*Perca fluviatilis, ahven* in Finnish), PIKEPERCH (*Sander lucioperca, kuha* in Finnish) and RUFFE (*Gymnocephalus cernua, kiiski in Finnish*). Perch is a common fish in Finland, and it can survive in very diverse environments. It lives throughout the country and spawns in early spring. Perch are easy to catch with various simple fishing gear such as hooks, nets, seines, traps, and weirs throughout the year. Pikeperch, in turn, is a species of warm waters and lives on the edge of its range in Finland up to southern Lapland. It thrives in lush waters and spawns at the end of spring. Of the simple fishing methods, gillnets are the best gear for catching pikeperch. Today, the recreational fishermen ice angle pikeperch with jigs through a hole in the ice. Both perch and pikeperch are very tasty and a valued food source. On the other hand, ruffe is a small slimy fish that is not currently valued as food. However, its meat is as tasty as perch or pikeperch. During historical times, ruffe was fished a lot with hooks, weirs and small-mesh gillnets. Ruffe is a groundling fish spawning in early spring, and appears all over the country except for the northernmost Lapland.

PIKE (*Esox lucius, hauki* in Finnish) lives in inland waters and coasts throughout Finland. In addition to perch, it is the most common but not the most abundant species in inland waters. This means that the species is widespread and lives in numbers in many regions, but its individual numbers in these areas are fewer than, for example, the small fish living in large shoals. Pike is modest in its environmental requirements, and thrives in a wide variety of waters. Pikes spend most of their time year-round on the shallow beach among vegetation and move quite little. Pike spawn in the spring but can be caught year-round with various simple fishing gear such as hooks and lines, seines, nets, and weirs.

BURBOT (*Lota lota, made* In Finnish) is a freshwater species belonging to the family of codfish. It is a delicious, mysterious groundling fish of cool waters. Burbot live all over the country in inland and coastal waters and, after perch and pike, it is one of the most common fish species in Finland. It thrives in deep, cool, and oxygenated waters. Burbot spawn in winter in January – February along the shoreline. In summer, large individuals live deep in the open waters, but small burbots can even be found in the beach zone under the rocks. Burbot is caught mainly under the ice during the winter spawning time. In the old times the most common fishing gear for burbot was a wooden three-pointed gorge (*nokkanen* in Finnish) made of juniper. It can also be caught in a net or a weir set under the ice.

WELS (*Silurus glanis, monni* in Finnish) are Europe's largest freshwater fish. The species was extinct in Finland in the 19th century. One cause of the loss could be the longer-term cooling of the climate. According to tradition, in the 18th century a 170-kilogram wels was caught in Vanajavesi in southern central Finland. This groundling species is a mostly nocturnal fish, whose spawning time begins when the water temperature rises to 20 ° C in summer (Raitaniemi 2001). There are no current data for the particularly suitable fishing methods for wels, but the other groundling fish are caught with hooks, nets, and weirs.

SALMONIDS (Salmonidae, *lohikalat* in Finnish) are fatty, valued fish of delicious taste. All species, including those living in the sea, spawn in fresh or brackish water. Salmonids mainly spawn in autumn, except GRAYLING (*Thymallus thymallus, harjus* in Finnish), which spawn in spring. There are five salmonid species living in Finland worth mentioning here: WHITEFISH (*Coregonus lavaretus, siika* in Finnish), salmon (description is among the brackish species), TROUT (*Salmo trutta, taimen* in Finnish), ARCTIC CHARR (*Salvelinus alpinus, nieriä* in Finnish), and grayling.

Whitefish lives throughout Finland in inland and coastal waters. Whitefish is probably our most diverse species of fish. Previously it was thought that the Finnish stock was divided into up to eight separate species due to different spawning places and times and the varying number of strainer teeth. However, enzyme genetic research and DNA analyses have revealed that this is just one species, *Coregonus lavaretus* (Raitaniemi 2001; Yrjölä et al. 2015). Some whitefish shoals start to spawn already in September, while others spawn after mid-winter. The most common spawning time is October-November. Whitefish thrive in a wide variety of waters, but there must be enough oxygen, that is, flowing or mixing water, and a depth allowing a cool water layer even during the summer heat. The net is definitely the most important gear for catching whitefish today, and seines have also been used in old times.

Trout is a migrant fish that lives throughout Finland. It has three ecological breeds, sea trout (*S. trutta trutta, meritaimen* in Finnish), lake trout (*S. trutta lacustris, järvitaimen* in Finnish), and brown trout (*S. trutta fario, purotaimen* in Finnish) living in brooks. Trout spawn in the river or brook in the autumn, and requires cool and oxygenated water. A much more exotic salmonid fish is the arctic charr, the northernmost inland water fish in the world. Arctic charr is the fish of the northern, cold, clear, and oxygen-rich waters. In Finland it occurs only in the mountain lakes of northern Lapland and a small stock in the Vuoksi water system in south-eastern Finland. The spawning time of arctic charr is from September to November. The best gear for catching trout or arctic charr are gillnets and hooks and lines. Grayling, the only spring-spawning salmonid fish, has been widely caught in historical times with seines and landing nets, especially during the spawning time. Grayling live alone or in small flocks in rocky shores of lakes and in rivers, and needs running and oxygen-rich water for spawning. In Finland, it has a northern distribution.

Last, but not least, I present here the family of the CYPRINIDS (Cyprinidae, *särkikalat* in Finnish), the family of the most numerous fish species in European inland waters. Cyprinids spawn in spring or early summer. They are a fish with many strong bones and therefore, among other reasons such as the ease of buying farmed salmon and rainbow trout from the markets, are often not valued as food today. Fortunately, this is changing after all the talk about responsible fishing, and Cyprinids have returned to Finnish dinner tables in recent years. There are 10 freshwater Cyprinid species worth mentioning here. Firstly larger-sized BREAM (*Abramis brama, lahna* in Finnish) and IDE (*Leuciscus idus, säyne* in Finnish), commonly used as food, live throughout the country except for the northernmost Lapland. Bream lives and spawns in shoals while ide is called as the Flying Dutchman of the fish world. It goes where it wants and suddenly appears how it likes. The ide-like CHUB (*Leuciscus cephalus, turpa* in Finnish) lives in the flowing waters and estuaries of the south coast. All three of these large-growing fish can be fished with a variety of fishing gear, such as seines, nets, landing nets, hooks and lines, weirs, traps, and the large individuals also with spears and leisters, from and near the shoreline.

Four small, commonly occurring Cyprinid freshwater fish are ROACH (*Rutilus rutilus, särki* in Finnish), RUDD (*Scardinius erythrophthal-*

mus, sorva in Finnish), WHITE BREAM (*Blicca bjoerkna, pasuri* in Finnish) and BLUE BREAM (*Ballerus ballerus, sulkava* in Finnish). Roach is very abundant and lives in all kinds of waters throughout Finland except for northernmost Lapland. The three other species live in southern and central Finland. Rudd, white bream, and blue bream thrive especially in waters with a lot of aquatic vegetation. All four species are easy to catch with hooks, nets, seines, and traps from the shoreline.

CRUCIAN CARP (*Carassius carassius, ruutana* in Finnish) appear in Finnish inland waters, with the exception of the northern part, and in brackish waters in the Gulf of Finland and the Archipelago Sea between south-western Finland and Åland. It is able to manage in cold water (in winter) for some time without oxygen, and thus also survives in ponds where other fish do not live. The spawning time is lenghty, from late May to early August. TENCH (*Tinca tinca, suutari* in Finnish) live in southern Finland. It is a night-active groundling fish of warm waters with rich vegetation, and spawn in midsummer. Tench can grow to large size but even larger is ASP (*Aspius aspius, toutain* in Finnish), a predatory Cyprinid fish of flowing waters and larger lakes with a high oxygen requirement. Asps live in Southern Finland at its northern boundaries. All of these three species are mostly fished with nets and hooks, crucian carp and tench also with weirs, and the small crucian carps living in ponds, popular especially as live-baits, also with traps.

4 Ethnographic background

4.1 Fishing among Northern foragers

Fishing has been a major form of subsistence for forager communities living close to bodies of water around the world (e.g., Nelson E. 1899; Birket-Smith 1929; Zolotarev 1938; Spencer 1959; Levin & Potapov 1964; Okladnikov 1964; Lee 1968; Larsen 1973; Slobodin 1981; Sturtevant 1981; Nelson R. 1986; Virrankoski 1994; Fagan 1995; Glavatskaya 2006a; 2006b; Jarvenpa & Brumbach 2006; Losey & al. 2008; Boethius 2018). For the small population of prehistoric and historic foragers, waterways were likely thought to have been an inexhaustible food storehouse, and fishing has long been a very sustainable source of sustenance for humankind thanks to a strong knowledge of nature and the life cycles of the fish. Nowadays, however, people have begun to be concerned about fish resources as a result of the unsustainable growth of the population (e.g., Iudicello et. al 1999; Morales Muñiz 2007; Worm & Branch 2012). Some of the food fish that have been available from time immemorial are now in danger of extinction as a result of overfishing, and also the blocking of their migration routes by closing rivers with dams, thus preventing the fish from entering their spawning grounds (e.g., Lehtonen & Varjo 2017).

In this chapter I will present a short overview of the forager fishing traditions in the northern subarctic region that most of Finland belongs to. The current scientific fish names and the common names in English have been checked in *fishbase.se* and the Finnish common names in Varjo et al. 2004. The scientific names of the Finnish fish species, many of which also live in northern Asia, were presented thoroughly in the previous chapter 3 *Environmental background*.

Fishing had already developed as a widespread activity by Upper Palaeolithic times in Europe. This assumption is based on the abundance of fish bones, the frequency with which fish are represented in cave art, and the occurrence of fishing gear in Palaeolithic finds. Fishing spears, leisters, and gorges are likely to have been developed during this period (Clark 1948; Pokines & Krupa 1997; Morales Muñiz 2007; see also Hoffecker 2005). Pike, trout, dace *(Leuciscus cephalus)*, chub, bream, white bream (Clark 1948), and salmon bones have been found in Upper Palaeolithic caves in northern Spain and southern France (Clark 1948; Pokines & Krupa 1997; Adán et al. 2009). People had elevated nitrogen stable isotope values in their bone collagen already in the Early Upper Palaeolithic, more than 30 000 years ago in Oase cave in Romania and the Kostenki I site in Russia, which indicates the consumption of large numbers of freshwater fish (Richards 2009). Both of these sites are situated close to freshwater sources (Richards 2009).

4.1.1 Northern Asia

Fishing has been important in southern and southwestern Siberia since the colonization of these regions during and after the latest Ice Age. The Russian researcher A. Zolotarev (Zolotarev 1938) wrote about the late Pleistocene Palaeolithic subsistence strategies in the "Siberian pocket", between glaciers and swamps in permafrost, in upper Irtysh, the Ob and Yenisei regions, and a narrow strip of land which reached to Yakutsk. Dwellings were located on the seashores and river-banks. Fishing was the basis and main livelihood there in north Asia all year-round, including in winter through ice holes. Zolotarev bases this argument on the original condition of the Siberian forests, with deep soft snow, where hunting elks *(Alces alces)* or reindeer *(Rangifer tarandus)* in winter was impossible without snowshoes or skis, which the Palaeolithic people did not have (see also Birket-Smith 1951). Northern summer is and was chiefly a fishing season, so fishing in winter and summer offered the most important livelihood, while deer were caught basically during the migration seasons in spring and autumn, in addition to the fishing that took place during those seasons. Reindeer husbandry was not yet practiced.

A.P. Okladnikov (Okladnikov 1964) emphasized the importance of mammoth hunting in the colonization of Siberia, but also mentions the widespread use of fish as food. At the Palaeolithic Oshurkovo site on the Selenga River near Lake Baikal, the discovery of harpoons and numerous fish bones show that fishing played an important role in everyday life (Okladnikov 1964; see also Vasil`ev 2003), and unidentified fish bones as well as fish hooks and harpoons have also been found in several other Early Holocene sites by the Rivers Yenisei and Angara (Klein 1971). In Siberia, inhabitants had become settled fishermen during the transition from the Palaeolithic to the Neolithic (Zolotarev 1938). By this time, the people of the North Pacific coast in the Russian Far East, as well as in the American Northwest coast, may have embraced seasonal salmon-fishing (Tabarev 2011). In the area of the Rivers Volga and Oka, bones of various freshwater fish - pike, perch, pikeperch, ruffe, whitefish, bream, tench, crucian carp, ide, roach, burbot, and wels - have been recovered at Early Mesolithic wetland sites (Zhilin 2014). In the northern coastland of Siberia, sea mammal hunting was also practiced, but the basic economy of the Siberian ancient culture relied on fishing (Zolotarev 1938).

In later Siberian cultures, subsistence was more variable, ranging from mobile to sedentary, from fishermen to sea mammal-hunters and reindeer-herders. Fishing was the principal means of subsistence throughout the year for the sedentary fishermen living in the Amur and Ob basins. This type of economy was characteristic of the Nivkhi, Nanays, Ul´chi, Itel´mens, Khanty and some of the Sel´kups and Ob´ Mansi (Levin & Potapov 1964).

The Khanty (earlier known as Ostyaki) living in the north of western Siberia and the Mansi (earlier known as Voguls) as their neighbours compose an ethnic group known as Ob-Ugrians belonging to the same Finno-Ugric language group as the Finns. The Khanty and the Mansi have practiced fishing since the Stone Age using a variety of methods, including fish traps, one of the earliest known types of fishing gear. The subsistence in these areas have remained relatively unchanged since the Stone Age, until recently. (Glavatskaya 2006a). It is argued that although reindeer are visually prominent in the Khanty landscape, fish has been the staple food that appears most regularly in the daily diet (Manninen 1929; 1932; Jarvenpa & Brumbach 2006). Among the Khanty, both men and women participate in fishing equally, and children are also involved. The Khanty preserve fish, especially pike and cyprinids, by drying and smoking, and store it for the winter (Manninen 1929; 1932; Glavtskaya 2006b). The dogs are also fed with fish, and during historical times the Khanty have even tamed their reindeer with fish (Glavtskaya 2006b). The river Ob gives a rich fish catch from spring to autumn when the migratory species of Siberian sturgeon (*Acipenser baerii, siperiansampi* in Finnish), nelma (*Stenodus nelma, nelma* also in Finnish), and muksun (*Coregonus muksun, muksunsiika* in Finnish) are abundant. In addition to this, smaller rivers and lakes with non-migratory freshwater fish give food all year round. The most common of these fish are pike, perch and four species of cyprinids: ide, roach, crucian carp, and bream (Glavatskaya 2006a). Similar fish have been recovered at the archaeological sites in the area, such as pike, perch, ruffe, and ide (Glavatskaya 2006b). Glavatskaya (2006b) also suggests that most fishing in ancient times was conducted in locations close to the settlements, as is also the case in contemporary Khanty life.

4.1.2 North American Eskimos

Fishing was an important source of food, along with maritime mammal hunting, among the western Eskimos (Nelson E. 1899). In Alaska, both the coastal Taremiut and the inland Nunamiut Eskimos fished seasonally, the Taremiut only in summers and the Nunamiut both in summers and winters, in winters through ice holes (Spencer 1959; Larsen 1973). Fishing was focused on the fresh water of inland lakes and streams, but the maritime species eulachon (*Thaleichthys* *pacificus, kynttiläkuore* in Finnish) and polar cod (*Boreogadus saida, jäämerenseiti* in Finnish) were fished from the seashore during their spawning times, eulachon in summer and polar cod in winter with nets through ice holes (Spencer 1959).

The Taremiut and the Nunamiut Eskimos fished polar cod with hooks. Many of their line sinkers were polished in the shape of a fish or a larva. Fish were also stored in ice cellars for later use, along with the meat of the hunted mammals (Spencer 1959). Edward William Nelson (Nelson E. 1899) mentions Eskimos fishing tomcod and sculpin in the spring in Alaska with hooks and lines under the ice and various species of salmonid fish later in the year with the same method. It is unclear whether Nelson means polar cod instead of tomcod, since the actual tomcod (*Microgadus tomcod, jääturska* in Finnish) lives in the Atlantic and the Pacific tomcod (*Microgadus proximus,* no Finnish name mentioned in Varjo et. al 2004) is also a different species, but the polar cod looks similar to tomcod and might have been called tomcod among the people. Many of the common names of the fish species have also changed over the decades. The sculpin that E. Nelson mentions could be one or more of the several species of the family Cottidae living in Alaskan waters. The western Eskimos also had seines, gillnets, and fish traps. Traps were especially used for the Alaskan blackfish (*Dallia pectoralis, viuhkakala* in Finnish), and gillnets for various salmonids.

The Kobuk River valley in northwest Alaska has been inhabited from the Palaeolithic period to this day. Much archaeological and ethnographic research has been done in the area. The earliest finds have cultural links with Siberian Palaeolithic cultures, and the valley has likely been inhabited by many different peoples over time. The Stone Age dwellings have been studied in particular, and have been mostly interpreted as winter settlements. Fishing gear from this period has hardly survived, so there is no definite information on the importance of fishing during the Stone Age. However, the importance of the Kobuk River to later peoples has been significant. The Kuuvaŋmiut Eskimos have inhabited the Kobuk River valley since about 1000 CE, and they are, above all, people of the river. Fishing has provided the most reliable subsistence resource and has been the primary source of subsistence for both people and dogs throughout the ages, practiced with long-surviving fishing methods. (Anderson et al. 1998).

The most important fished species among the Kuuvaŋmiut people as mentioned by the ethnographers are sheefish (*Stenodus leucichthys, nelma* in Finnish), arctic char (*Salvelinus alpinus*), lake trout (*Salvelinus namaycush,* harmaanieriä in Finnish), humpback whitefish (*Coregonus pidschian,* Finnish name not found), broad whitefish (*Coregonus nasus,* pyörökuonosiika in Finnish), least cisco (*Coregonus sardinella*, siperianmuikku in Finnish), round whitefish (*Prosopium cylindraceum*, pyörösiika in Finnish), chum salmon (*Oncorhynchus keta, koiralohi* in Finnish), grayling (*Thymallus arcticus, pohjanharjus* in Finnish), burbot (*Lota lota*), northern pike (*Esox lucius*) and northern sucker (*Catostomus catostomus*, imukarppi in Finnish). These species include both migratory fish and local freshwater species (Anderson et al. 1998).

Gillnets and seines of the Kuuvaŋmiut Eskimos have been made of woven willow bark and split spruce roots with wooden netting shuttles. The mesh size of the seines has been smaller than that of the gillnets, so apparently the seine has been used for smaller fish. The structural difference between seine and gillnet, other than mesh size, is in the design of the floats and sinkers. Seine floats are usually elliptical with flat bottoms, so that they offer minimal resistance to the water when being pulled in. Sinkers are usually cylindrical sections of caribou (*Rangifer tarandus*) antler. The Kuuvaŋmiut Eskimos have also fished with poles, hooks, clubs, gaffs, spears, and dip nets. Another important type of fishing gear has been a variety of wooden weirs and traps, with and without fences to harvest autumn fish runs. Gillnets and weirs have also been used in winter under the ice, as well as hooks and lures. The primary target of ice fishing was burbot, which was caught with traps and trot lines with special burbot hooks. The Kuuvaŋmiut Eskimos have used special fish-drying racks where fish have been dried after cutting, and different kinds of caches to store the dried fish. (Anderson et. al 1998).

Spencer (1959) mentions that fishing among the Alaskan Eskimos in historical times was a woman´s activity, although men assisted in setting out the nets. Among the Kuuvaŋmiut Eskimos, women have mainly fished with seines and gillnets, but men have often assisted them, and men have carved net floats and sinkers. Older men have also fished instead of hunting to stay productive and nowadays men also fish for fun (Anderson et al. 1998). All in all, the division of subsistence activities between the sexes is most likely local, so from these few references, it cannot be concluded that fishing was primarily the work of women in Alaska. In some cultures, men have certainly been involved in fishing as much or more than women.

In addition to the Alaskan Eskimos, the Caribou Eskimos in Canada had an advanced fishing culture and used many widespread methods and types of gear for fishing including hooks, jigs and line sinkers, double-pointed gorges, weirs, and seines (Birket-Smith 1929). The central Eskimos in north-eastern Canada fished mostly salmon with spears, hooks, and nets. In autumn, salmon can, when ascending the river, even get stuck in small ponds when the river dries quickly. Fish are easy to catch in these ponds, and the ponds also serve as food stores when they freeze to the bottom in winter; the natives have even picked frozen fish through holes in the ice (Boas 1964). According to Richard B. Lee, many of the Eskimos at all latitudes have depended primarily on fishing, which is a much more reliable source of food than the hunting of land and sea mammals (Lee 1968).

4.1.3 Subboreal forest zone Native Americans

In the Native American communities in Canada, there was no need to fear that the supply of fish would come to an end; there were fish was enough in the seashore and in the vast lake areas of the Canadian Shield. In these areas, fishing has been the most important source of subsistence for some tribes, and for others of equal importance with hunting. Fishing has been practiced with clubs, nets, traps, weirs, hooks, leisters, harpoons, spears, and even bows and arrows. Salmon runs have been important seasonal fishing events in the autumn, and in the wintertime Canadian Native Americans fished with gillnets under the ice. The fish was also dried and stored for more uncertain times. Even today, some Canadian Native Americans live as fishermen. (Sturtevant 1981; Virrankoski 1994; Fagan 1995).

According to the ethnographic literature of North American subboreal Native American cultures (e.g., Sturtevant 1981; Trigger 1985; Virrankoski 1994), caribou *(Rangifer tarandus)* and moose *(Alces alces)* hunting was the main source of meat for the tribes that lived in the Canadian forests. The importance of fishing in some regions was great, but usually the fish was the main meal only during times when game was hard to get. Some peoples even avoided fish (Sturtevant 1981; Virrankoski 1994). However, in the same ethnographic literature, it is mentioned in the subordinate clauses that in many hunter communities the daily diet frequently was either freshwater fish or freshwater fish together with small game, instead of thought-to-be-preferred big game or salmon. Ideas are often different from reality. Thus, freshwater fishing has likely been a more secure basis for subsistence than hunting or spawning-time seasonal salmon fishing (Sturtevant 1981). Inland, fishing has been more of a woman's job (Virrankoski 1994). For instance, the Iroquois men went hunting in the winter when women and children lived more in permanent fishing villages (Trigger 1985). It is possible that the ethnographic information often undermines the importance of fishing, as it was done by women and children. However, already during the late 1960s in the symposium "Man the Hunter", it was understood that small-scale women's gathering, and fishing have been more important than men's hunting in the daily diet of native cultures, except perhaps in the most Arctic areas (Lee & DeVore 1968).

In Alaska and the Yukon boreal forest regions, among the Kutchin (Gwich´in) Native Americans, fish has been one of the richest and most reliable food resources (Slobodin 1981; Nelson R. 1986). According to R. Nelson (1986), fish was the single most important resource in the Kutchin Native Americans´ past. The Kutchin (Gwich´in) Native Americans fished year-round with various fishing methods along the shoreline, river banks, and inland waters. The regular and significant fish species in the local economy were the anadromous chum salmon (*Oncorhynchus keta, koiralohi* in Finnish) and coho salmon (*Oncorhynchus kisutch, hopealohi* in Finnish), and the freshwater species whitefish (*Coregonus* sp.), sheefish (*Stenodus leucichthys, nelma* in Finnish), burbot (*Lota lota)*, northern pike *(Esox lucius)* and grayling (*Thymallus arcticus, pohjanharjus* in Finnish). The Kutchin (Gwich´in) Native Americans were selective about different fish and parts of fish and fish eggs. Some parts were considered delicious to eat but some parts were considered strictly dog food. Like the Khanty in Siberia, many other Native American tribes also fed their dogs with fish (Sturtevant 1981; see also Jarvenpa & Brumbach 2006). On this basis, fishing must have been profitable, as it enabled the selective use of fish separately for people and dogs.

The Chipewyan Native Americans in north-central Canada were both hunters and fishers. Fish was an important source of food for humans and dogs, and was practiced mostly with gillnets in inland waters. Both men and women participated in fishing as well as hunting. The main fish catch consisted of eight species of freshwater fish: lake whitefish (*Coregonus clupeaformis, sillisiika* in Finnish) being the most important, but also including northern pike, burbot, walleye (*Sander vitreus, valkosilmäkuha* in Finnish), lake trout (*Salvelinus namaycush, harmaanieriä* in Finnish), cisco (*Coregonus artedi, amerikanmuikku* in Finnish), white sucker (*Catostomus commersonii, valkoimukarppi* in Finnish) and longnose sucker (*Catostomus catostomus, imukarppi* in Finnish; Jarvenpa & Brumbach 2006).

The Native American cultures of British Columbia were highly specialized in catching marine mammals and fish (Fagan 1995). The main industry of the Northwest Indians was fishing, the most important of which was salmon fishing during the salmon run, but many other species were also fished with weirs, traps, nets, landing nets, and spears (Virrankoski 1994; Fagan 1995; see also Boas 1966). Each family had several permanent residences, which were occupied according to the annual phases of fishing. During the seasonal fishing season, they lived in small villages and in the winter season in bigger winter villages (Virrankoski 1994). The abundance of the ocean life enabled the development of these cultures (see also Trigger 1985), and they evolved over time to form high cultures, dating to almost 3,000 years ago (Fagan 1995).

4.2 Historical knowledge about ancient fishing methods in Finland

Fishing has always been one of the main sources of livelihood in Finland, and several historical and ethnographic books have been written about fishing methods. In the old times, fishing waters were used with methods appropriate to the annual behaviour of each fish species. The basis for Finnish fishing tradition research is the massive three-volume ethnographic book *Suomalaisten kalastus* (Fishing of the Finns) compiled by the first professor of Finnish ethnography, U.T. Sirelius, in the early 20th century (Sirelius 1906; 1907; 1908). The book was re-published as a single volume 459 -page illustrated edition in 2009 (Sirelius 2009), and is a detailed and comprehensive account of historical fishing in Finland. Many of the fishing methods described in the book have most obviously been in use already in the prehistoric period, some even in the Stone Age (e.g., Lappalainen & Naskali 1999; Koivisto 2012; Koivisto & Nurminen 2015; Koivisto 2017). In addition to Sirelius book, there are also many other descriptions of Finnish fishing that complete our historical knowledge (e.g., Manninen 1929; 1932; Itkonen 1937; 1944; 1948, Vilkuna 1974; Talve 1979; Vuorela 1983; Pennanen 1986; Naskali 1993; Lappalainen & Naskali 1995; 1999; Järvisalo 2004).

The Sámi in Lapland have lived at a subsistence level for a long time. Fishing has been described as the most important livelihood for most of the Sámi, except for the reindeer breeders who prefer meat (Holmberg 1915; Itkonen

1937; 1948). Jukka Pennanen (Pennanen 2006; see also Manninen 1929; 1932; Itkonen 1948; Nickul 1970) separates the Sámi into four groups: the Reindeer or Mountain Sámi (*poro-eli tunturisaamelaiset* in Finnish), who practiced nomadic reindeer herding, the Sea Sámi (*mer-isaamelaiset* in Finnish), who lived along the Arctic coast of Norway and were fishermen and farmers, the Fisher Sámi (*kalastajasaamelaiset* in Finnish), who lived in the region surrounding Lake Inari and in the valley of Teno River, and the Forest Sámi (*metsälappalaiset* in Finnish), who practiced traditional foraging subsistence until the 1700s.

The nomadic Sámi group from the north-east, the Skolt Sámi (*koltat* in Finnish), whose main subsistence was stated to be fishing, are said to be either a part of the Forest Sámi (Nickul 1970) or the Fisher or Sea Sámi (Itkonen 1948). In any case, the Skolts practiced the traditional foraging way of life by fishing, hunting and, later, also by reindeer herding (Itkonen 1948; Nickul 1970). Itkonen's book (1948) mentions the old phrase of the Skolt Sámi (my translation): "One does not dare to rely on the mercy of the forest, but the lake does not let a man die" ("metsän varaan ei uskalla jättäytyä, mutta järvi ei anna miehen kuolla"). Similarly, a Shungnak Eskimo elder of the Kuuvaŋmiut culture in Alaska has simply said: "We must have fish to live" (Anderson et al. 1998).

In the following I will present the fishing methods that may have been used in the Stone Age according to the historical data (see also Bērziņš 2010). Archaeological finds in Finland are presented in chapter 5.1 *Archaeological evidence of fishing*. In historical and ethnographic sources the fishing methods are divided into active and passive types (see more below), and they can be categorized into club fishing (hitting) and spearing, angling, weir fishing, seine fishing, and net fishing, and their combinations. It should be noted, however, that in Stone Age cultures such a division between active and passive methods may not ha been considered relevant.

4.2.1 Club fishing, spearing, and looping

Simple and active fishing methods such as club fishing (hitting), spearing, and looping require the catcher to see the fish hiding or swimming in the water. The use of this gear is more like traditional hunting, *jahti* in Finnish. The word *jahti* can be used to mean both hunting and fishing, the latter catching the fish by hitting, spearing or looping, and in the end, often picking the fish up with a landing net or scoop net (*haavi* in Finnish) (Lappalainen & Naskali 1995; 1999). One form of landing net is the hand (landing) net (*lippo* in Finnish), which is used mainly by scooping up the fish from the side or from the top, and has been popular especially in catching whitefish and smelt (*Osmerus eperlanus*, *kuore* in Finnish) (Sirelius 1907; 2009).

The Sámi have even fished graylings and whitefish that have risen into rivers to spawn with their bare hands (Itkonen 1937; 1948).

The most common form of club fishing during historical times has been the clubbing of fish under the ice during the first clear autumn days (Sirelius 1906; Itkonen 1937; Vuorela 1983; Lappalainen & Naskali 1995; 1999; Pennanen 2009). When the water freezes, the oxygen conditions for the fish change. The concentration of dissolved oxygen in the water is reduced, and fish stay in the shallow water just below the ice to compensate. The catches were mainly pike and burbot. In this case, the fishing gear was a simple wooden club (sometimes with a stone head) or the head of an axe. Pikes have also been caught by clubbing during their spawning time (Lappalainen & Naskali 1999).

Spearing, an old and simple fishing method for bigger fish, has been practiced using arrows, spears, harpoons and leisters (Sirelius 1906; Itkonen 1944; Lappalainen & Naskali 1995; 1999) from the shoreline or from a boat. Daytime spearing has taken place during historical times at the spawning grounds of the fish in bays, rivers, and brooks, and also from weirs. In the hot summer days, spear fishing has been successful in shallow, grassy water, where the fish bask for day. Harpooning and spearing has also been widely used in prehistoric Siberia and among the Alaskan and Canadian Eskimos in winter through holes in the ice (Nelson E. 1899; Birket-Smith 1929; Levin & Potapov 1964). Many western Eskimos in Alaska and the Yukon even had special arrows exclusively for such fishing, with one, two or three barbed points (Nelson E. 1899).

Night time torch fishing (*tuulastus* in Finnish) in the dark with leisters is a very old idea, and could have easily been used already in the Stone Age. Stone Age leister prongs have been found in regions nearby Finland (e.g., Clark 1948; Enghoff 1994; Grøn 2007; Hood & Helama 2010; Zhilin 2014; David 2018), although there is no evidence for the use of fire during this period. Nocturnal torch fishing has been practiced in August-September on windless, rainless, and cloudy nights, using fire. In spring, this method has also been used during daytime. The fish swim into the shallow water and are easy to catch when they reach the circle of the firelight. Big fish such as pike, bream, ide and whitefish were the most fished species with this method, and even salmon, burbot, grayling and eels were caught locally (Sirelius 1906; Vuorela 1983; Lappalainen & Naskali 1995; 1999). Nocturnal torch fishing has also been practiced in Siberian indigenous fishing cultures (Levin & Potapov 1964; Glavatskaya 2006a), among the Gold tribe in northern Manchuria (Lattimore 1933), as well as in British Columbia among the Northwest Native American cultures (Virrankoski 1994) and the Cree in the Hudson Bay area (Pennanen 1996).

The earliest leisters were probably made of tree branches. Straight or barbed spikes could have been attached to the sides of the wooden shaft. The spikes may have been made of horn, bone, or wood. To fasten the spikes, people may have used birch tar to bind them with a leather strap, or natural plant fibre (Vuorela 1983; Järvisalo 2004).

T.I. Itkonen and Johan Turi mention that the Sámi caught graylings in the spring, and whitefish and also some small fish in the autumn, from small brooks with the help of a loop (Itkonen 1937; Turi 1979). Pike have also been caught using loops (Sirelius 1906; Itkonen 1944; Lappalainen & Naskali 1995; Pennanen 2009). The loop was slowly and silently moved around a pike in shallow water, and the fish was then snapped up. A fishing device similar to the loop is a fish snare placed on the end of a stick, as used by the Canadian Eskimos (Birket-Smith 1929).

4.2.2 Angling with hooks and lines

Fishing with hooks and lines can be divided into two different methods, active and passive fishing. Angling with hook and line, when the fisherman holds the fishing gear, is an active method, while fishing with a double-pointed gorge (*launi* in Finnish) or triple-pointed gorge (also three-barbed wooden hook, *nokkanen* in Finnish) can be both active or passive fishing.

The triple-pointed gorge was made of juniper, or sometimes from a lower branch of spruce, with three sharp points (Figure 3). It has been used in catching bigger fish like burbot or pike, using small fish as a live bait (Lappalainen & Naskali 1995; 1999; Sirelius 2009). The burbot, for which these wooden hooks are likely to be used most often, swallows the bait with the gorge deep into the stomach and is thus caught. The straight double-pointed gorge, sharpened at both ends, is inserted lengthwise into a small live bait fish in the same way as the triple-pointed gorge (Clark 1948; Vuorela 1983; Lappalainen & Naskali 1995; 1999; Pennanen 2009). The Sámi also used triple-pointed juniper gorges to catch burbots during the winter spawning time, but double-pointed gorges were unknown to them (Itkonen 1937; 1948). Active burbot fishing was carried out in winter at night. In passive fishing, a line with a baited juniper gorge bound to a stake was left in the ice hole (Itkonen 1948).

Hooks for active fishing have been made of wood, bone, and stone, as well as combinations of these materials (Lappalainen & Naskali 1999; Pennanen 2009). A line weight is needed if the hook is made of a buoyant material. The material used for a line weight was usually schist or soapstone (Lappalainen & Naskali 1999) and the lines could have been woven from willow bast or nettle fibre (Pennanen 2009). Some line weights have been skilfully polished in the shape of a fish, when they are most likely associated with winter fishing and ice angling (jigging) through a hole in the ice (see more in 4.2.6 *The significance of ice fishing*). The ends of a line weight

Figure 3. Three-barbed wooden hook, length ca. 6 cm. Reconstruction made by Risto Järvisalo. Photo: Katariina Nurminen

Figure 4. Fish trap made of wooden shingles and netting in the house of Ivan Mironoff in Suojärvi, Karelia (former Finland, now Russia) in 1935. Photo: Auvo Hirsjärvi, Finnish Heritage Agency (KK1899:104), (https://finna.fi).

were grooved or drilled with one or two holes. The shafts of the hook could be made of wood, bone, or horn. The point is made of wood or bone (Lappalainen & Naskali 1999). The point can be attached to the shaft without binding, but the strength of the point and its bond can be helped by using resin or birch tar as a binder, which are resistant to water. A nettle fibre or a tendon yarn could also have been used as a binder (Järvisalo 2004).

As described above, fishing for bigger fish with gorges, as well as with primitive hooks, which are quite big and therefore suitable for catching larger fish, requires small fish to be used as bait. The use of fish bait implies the catching of predatory fish, such as pike and burbot. Small bait fish used in gorge fishing and angling, as well as in ice angling (jigging), could be easily caught in traps or small-mesh seines or nets (more about these types of fishing gear later on in this chapter). We know from the Sámi that they have used small-mesh nets to catch bait fish under the ice during the wintertime (Itkonen 1937).

4.2.3 Weir and trap fishing

Fishing with different kind of fish traps (*katiska, merta* in Finnish, Figure 4) and fyke nets (*rysä* in Finnish, Figure 5) requires the skill to build this particular fishing gear. However, they are easy gear for the fishermen to use once built, because they do not need the active presence of a human to catch fish. These types of gear have usually been used with fences. Fishing fences could be set in the water, blocking the way and guiding the fish towards the primary trapping system. Traps and fences have also been used in Siberian fishing cultures (Levin & Potapov 1964). The Ob´ Ugrian Khanty had several variations of stake fences ending in fish traps or bag-shaped nets (Prokofyeva et al. 1964).

Traps were often made of willow and bound with pine root yarn in northern Europe (Lappalainen & Naskali 1995). These kinds of traps are light and easy to move, and are suitable, for instance, for catching perches, cyprinids, and burbot.

Larger traps or weirs situated in larger rivers, for instance in the Kemijoki, Tornionjoki, Oulujoki, Tenojoki and Kymijoki rivers, were used to catch salmon during historical times. This kind of salmon fishing grew into a profession in the 17th-19th centuries, and was often run by large companies. Salmon catching as a profession ended with the industrial revolution and the introduction of power plants into the riverine systems (Talve 1979; Vuorela 1983; Lappalainen & Naskali 1999). In addition to salmon, the Sámi have used bigger traps for pike, grayling, and trout in the spring, while in the autumn the main catches have been whitefish and vendace (Itkonen 1937).

Weirs and traps are significant and old types of fishing gear, but the fyke net is apparently relatively young. It was supposedly adopted in Sweden as late as in the 12th century, and from

Figure 5. Fishing with a fyke net in 1951. Photo: Jussi Kangas, Finnish Heritage Agency (KK2833:35), (https://finna.fi).

there was passed on to Finland (Sirelius 2009: 435; Vilkuna 1974: 141).

The lath screen panel weir (*liistekatiska* in Finnish) is a type of stationary fishing gear built on a shallow flat-bottomed shore. It consists of fences, a throat or passage, and one or more heart-shaped nests. Pine laths would have been used as the materials. The laths were bound together with birch bark or thin birch branches or pine roots (Sirelius 1908; Lappalainen & Naskali 1995; 1999). Weirs built in the old time were usually built in early spring, when the water was still frozen, of narrow laths that were pressed to the bottom of the lake (Talve 1979). In the old times, the weir was especially used for catching bream, ide, pike, and big perch (Lappalainen & Naskali 1995) but was useful in catching all kinds of fish (Vuorela 1983).

4.2.4 Seine fishing

An important type of fishing gear for shoreline fishing was the seine, which came in several varieties (Sirelius 1907; Vuorela 1983). The seine is an active fishing device, an unmounted net, which is used by pulling it in the water and surrounding the fish (Figure 6). Sometimes landing/scoop nets were used after surrounding the fish to pick it up. When people still grew, hunted, and fished for their own food, seines were used everywhere near the shorelines. Besides Finland, seines were also used widely in Siberia (Levin & Potapov 1964) and in the Kobuk River valley, Alaska (Anderson et al. 1998).

The earliest form of the seine is thought to be a type made of fresh leafy branches of birch with the tops connected to each other, used to encircle the fish in shallow water (Sirelius 1907; Vuorela 1983; Lappalainen & Naskali 1995; 1999). Willow or another deciduous tree could also have been used for this seine type (Sirelius 1907). The same fishing concept has been used for example in Tahiti, where the seine walls were made of palm leaves (von Brandt 1984). I was originally supposed to build such a simple seine for this study and try fishing with it. In the summer of 2019, I was sailing in the Gulf of Finland while trying to find a suitable place to fish with a seine made of the fresh leafy branches of a birch. Unfortunately, no such place was found. In the archipelago, the water deepened everywhere too quickly from the steep shoreline for this kind of seine fishing according to the nautical chart. In addition, there were toxic cyanobacteria (e.g., Sivonen & al. 1989) everywhere in the water, so I did not want to expose myself to it, and pulling this kind of a seine is impossible from the sail boat. I then realized that this fishing method would probably be possible only in brooks, small rivers, or the shallow bays of lakes, and I did not know of a suitable place inland where I could go fishing at the time.

Figure 6. Seine fishing in Käkölä, Naantali, June 1914. Photo: T.H. Järvi, Finnish Heritage Agency (KK2969:166), (https://finna.fi).

Hopefully, I can practice this old-time experimental fishing sometime later in the future.

An ancient type of active seine fishing is "hot weather catching" (*hellepyynti* in Finnish), which was practiced on calm, hot summer days in sandy bays. In this fishing method, seines were used to surround fish and force them to the shore by wading in the shallow water. These seines were small-mesh gear woven from thick yarn, with a height of about one meter and a length of a little less than 20 meters. There were floats on the upper line to keep the net on the surface and sinkers on the lower line, so the net remained on the bottom as the catch progressed. (Naskali 1993; Lappalainen & Naskali 1995). In the Eastern parts of the Baltic, especially ides, roaches and vimba breams, all of them Cyprinid fish, were caught with this method (Naskali 1993).

Seine net fishing has also long been practiced in winter the through holes under the ice during historical times (Itkonen 1944; 1948; 1984; Talve 1979; Turi 1979; Vuorela 1983; von Brandt 1984; Pennanen 1986; 1987). The Sámi have also fished for pike, whitefish, trout, and also small fish with seines under thin ice (e.g., Itkonen 1948). Ice fishing with seines and other different fishing gear has been widely practiced around the northern latitudes and circumpolar regions since Palaeolithic times (see more in 4.2.6 *The significance of ice fishing*). In the River Näätämö, the Skolt Sámi have fished for salmon with a traditional seine called the "*käpälä",* which is thrown into the water, every summer from long in the past until today (Niemelä et al. 2015)

Primitive seine fishing is characterized by catching fish in small and easily closed waters (Sirelius 1989), that is, in such waters where the Stone Age dwellings were located.

4.2.5 Net fishing

Actual net fishing is a passive fishing method. The nets with floats and sinkers, also called gillnets, are left in the water to catch the fish. The fish gets caught in the grid of the net by its gills. Sirelius (1989) supposes that fish nets were probably developed from seines. The earliest evidence of fishing in Finland is the famous fishing net, woven from willow bast, found in Antrea in the Karelian Isthmus, with an estimated age of over 10,000 years (see more in chapter 5.1 *Archaeological evidence of fishing)* (Pälsi 1920; Edgren 1984; Huurre 1998; Carpelan 1999; 2008). In many Siberian indigenous cultures, nets were woven from nettle fibre (Levin & Potapov 1964; Glavatskaya 2006a). The Alaskan Eskimos have mostly used willow bast (Nelson E. 1899) or braided willow bark (Anderson et al. 1998), and willow bast has also been used among the West Main Cree Native Americans in the Hudson Bay area (Sturtevant 1981).

Along with seine fishing, gillnet fishing is also possible in winter under the ice through holes. Ice fishing with nets (Figure 7) has been

Figure 7. Winter fishing with a net under the ice through holes, at Larjatskoje, Vah, Siberia, Russia in 1898. Photo: U.T. Sirelius, Finnish Heritage Agency (SUK36:349), (https://finna.fi).

a very important form of fishing for the Sámi (Itkonen 1948; Pennanen 1987).

Net fishing is still common in Finland today, both in lakes and along the seashore. Ordinary people use nets to catch fish for their home dinner tables. The nets are dropped into the water from a boat. A float, which can even be a common empty juice can with a handle, remains behind as a sign so that the net can be found and gathered up with the fish the next day. As a child, I used to net fish with my late father every summer when we were on holiday at his childhood home in Virolahti, on the seashore of the eastern Gulf of Finland. I remember us catching especially perch, pike, and some cyprinids, which I did not recognize by species back then.

4.2.6 The significance of ice fishing

Winter fishing through a hole in the ice has been a rather common practice in northern cultures stretching from Eurasia to America. In northern Asia, fishing through ice holes with jigs (ice angling), nets, traps, leisters, and harpoons has been a widespread fishing practice from the Stone Age until historical times (Zolotarev 1938; Okladnikov 1964; Pennanen 1987). Besides Siberians and central Asians, the Ainu in Japan knew ice fishing with leisters according to an old Japanese painting on silk (Birket-Smith 1929), and the Gold in Northern Manchuria, northeastern China, ice-fished with lines (Lattimore 1933). According to Zolotarev (1938), without ice fishing humans could not have inhabited the northern Asian regions (see also Nilsson 1972: 275; Pennanen 2009).

In North America, the Eskimos in Alaska and Yukon, as well as the Canadian Eskimos and other Eskimos all the way to Greenland, fished through ice holes with nets and hooks (Nelson E. 1899; Spencer 1959; Larsen 1973; Pennanen 1987; Anderson et al. 1998; see also Boas 1964). For instance, the downriver Kobuk people caught, in addition to burbot, sheefish with a special lure carved in the shape of a fish

(Anderson et al. 1998). Nets were used except in the very coldest regions where ice fishing was practiced mainly with spears and harpoons (Pennanen 1987). The development of ice fishing into seal hunting through breathing holes has even been argued as being one of the foundations of American Eskimo culture, when people moved from northern Asia to North America (Birket-Smith 1951).

Some Canadian Native American groups fished through holes in the ice using harpoons (Birket-Smith 1929). Ice fishing with gillnets, seines, jig hooks and spears has widely been practiced among North Native American cultures (e.g., Sturtevant 1981; Nelson R. 1986; Pennanen 1987; Virrankoski 1994; Fagan 1995). Winter gillnets were set in the lake and provided, for example, burbot, pike, and whitefish (Sturtevant 1981).

In Finland, ice fishing with hooks, nets, and seines is a long tradition, and especially jigging is still widely practiced among recreational fishermen.

In the cold winters of the North, food resources are scarce. Plants hibernate during winters, and although berries and nuts may have been preserved for winter and spring, most plants are unavailable, while hunting can be uncertain and require a lot of effort. In contrast, fish are a reliable source of food in lakes and other inland waters. Although fishing has been a part of the annual cycle for many forager cultures, it can be practiced year-round in fresh water (see also Bērziņš 2010). Since fish species in the inland lake ecosystem do not seasonally migrate long distances, but mainly stay within the same lake and river basin, the forager people did not have to follow them from place to place (see also Nuñez 1990); they could use their knowledge of nature and the life cycle of fish without the need to migrate themselves.

Ice fishing does not require much effort, mostly only patience when actively fishing with hooks and lines, spears, or leisters. In addition to these types gear, nets and traps can also be used in ice fishing as a passive method, being left to catch the fish by themselves. Therefore, fishing allows for year-round living in an inland area where other food resources are uncertain or insufficient during the wintertime and early spring (see also Pesonen 1996).

4.2.7 Summary of fishing methods

As a summary, according to historical and ethnographic sources, fishing methods and fishing gear have been very similar all over the circumpolar zone (see also Birket-Smith 1951), as well as elsewhere in the world (e.g., von Brandt 1984; Morales Muñiz 2007; Bērziņš 2010). All of the ethnographic literature mentioned in this chapter describe the same kinds of fishing hooks, spears, leisters, weirs, traps, seines, and nets, as it seems that these types of fishing gear were universal. These simple fishing methods are especially suitable for catching fish from and near the shoreline, and are particularly useful to a person who is familiar with the behaviour and life cycle of fish and is able to utilize their knowledge of nature to make fishing an effective livelihood. Because Stone Age people lived as a part of nature, there is no reason to doubt that they possessed these skills. Consequently, it is likely that even today, our current fishing methods have their roots in ancient times, in the early history of humans.

5 Archaeological background

Finland has been inhabited since the retreat of the Ice Age ice sheet, from the Mesolithic Age (ca. 8850-5200 BCE) (Takala 2004; Pesonen et al. 2014; Tallavaara et al. 2014; Halinen 2015). The Mesolithic transitioned to the Neolithic (ca. 5200-1900/1700 BCE) with the advent of ceramics (Halinen 2015). Unlike in Central Europe, the boundary between the Mesolithic and Neolithic in Finland is precisely tied to the adoption of pottery, because the agriculture associated with the Neolithic in Europe did not appear in Finland until the end of the Stone Age. Therefore, in Finland, the Neolithic is on many occasions referred to as the "Subneolithic" (Gimbutas 1956; Meinander 1961) or "pottery-Mesolithic" (Pesonen & Leskinen 2009). Except for the adoption of pottery, the foraging lifestyle continued as before.

The Mesolithic Age is divided into three periods: Early (ca. 8850-8000 BCE), Middle (8000-6800 BCE) and Late Mesolithic (6800-5200 BCE). The Neolithic Age in Finland is divided into ceramic styles, but it can also be simplified, as with the Mesolithic, into the Early (5200-3900 BCE), Middle (3900-3200 BCE), and Late Neolithic (3200-1900 / 1700 BCE) (Halinen 2015). Especially in eastern and northern Finland, for instance among some of the Sámi groups (see *4.2 Historical knowledge about ancient fishing methods in Finland*), the Mesolithic lifestyle continued even after the Stone Age (Holmberg 1915; Manninen 1929; 1932; Itkonen 1948; Nickul 1970; Pennanen 2006). Since the classification of ceramics is irrelevant to fishing, I use the division of the Neolithic into early, middle and late stages. I also use the term Neolithic instead of Subneolithic, because it is clearer, and Subneolithic literally means some kind of subculture of the Neolithic Age itself.

Life in Stone Age Finland was diverse, depending on local environmental conditions, human communities, and connections elsewhere. Everyday life was built around food: hunting, fishing, and gathering. Foraging people shared the natural habitats of game, fish, and plants. In Finland, the snowy and cold winters brought their own challenges to survival. (Huurre 1998; Halinen 2015).

5.1 Archaeological evidence of fishing

Sakari Pälsi, a famous Finnish archaeologist and ethnologist, wrote already in 1916 in his book *Kulttuurikuvia kivikaudelta* (Pälsi 1916): "It can be said that fishing was the main livelihood of the Finnish Stone Age" (my translation). The same idea about the importance of freshwater fishing as the primary food supply in Stone Age Finland has been suggested by many archaeologists over the years (e.g., Luho 1948; Siiriäinen 1980; Nuñez 1990; Mökkönen 2001). The ancestors of the post-glacial populations of present-day Finland lived along the great rivers of Russia (e.g., Fogelberg 1999; Niskanen 2002; Rankama & Kankaanpää 2008; Jussila et al. 2012), where freshwater fishing has been a major source of subsistence in many areas since Palaeolithic times (e.g., Zhilin 2014; see also chapter 4 *Ethnographic background, 4.1.1 Northern Asia*).

Fishing gear finds and fishing in general have been touched upon by other archaeological studies (e.g., Pälsi 1916; 1920; Äyräpää 1950; Edgren 1967; 1970; 1984; Nuñez 1990; 1999; Rankama 1996; Ukkonen 1996; Schulz H-P 1997; 1998; Huurre 1998; Carpelan 1999; Mökkönen 2001; Kankaanpää 2002; Leskinen 2002; Halinen 2015). Actual fishing gear and methods have only been studied quite recently (Minkkinen 1999; 2000; Naskali 2004; Carpelan 2008; Koivisto 2012; Koivisto & Nurminen 2015; Koivisto 2017). However, in Finnish archaeology, the importance of fishing has still often been forgotten. Perhaps the reason has been the general focus on stone tools and ceramics, seen as necessary to study the evolution of society in general, instead of subsistence. Perhaps the majority of past researchers have been men whose personal interest in hunting diverted attention from fishing. Another, simple reason may be the scarcity of preserved fishing gear and the effects of traditional excavation methods, which did not favour finding small fish bones. As the Danish ethnologist Kaj Birket-Smith expressed it (Birket-Smith 1951): "Fishing is not surrounded by a similar glow of romance as hunting".

Some fishing gear, mostly made of stone, has been found in Stone Age contexts in Finland (see below). However, most of the fishing gear was probably made of organic materials and has therefore disappeared after millennia in the soil (e.g., Pärtel & al. 2004).

5.1.1 The Antrea net and its knotting

The earliest evidence of fishing in Finland is a fishing net found at Korpilahti in Antrea on the Karelian Isthmus, with an estimated age of over 10,000 years. The radiocarbon dating of the net is 9140 ± 135 BP (Miettinen et al. 2008), which corresponds to 8732-8162 calBCE after calibration (OxCal 4.3, Bronk Ramsey 2009). The net apparently fell from a boat into the water, or the artefacts might have been broken through some (possibly unexpected) weakened ice in winter. The net dropped onto a clay sea floor and has therefore survived for millennia (Pälsi 1914; 1920; Carpelan 2008). The fishing net was woven from willow bast and its floats were made of pine bark. The yarn is double-stranded. Based on the number and location of floats and sinkers, its length is estimated to have been 27-30 meters with a height of 150-170 cm. When wet, it may have weighed about thirty kilograms, of which the sinkers account for about half. (Pälsi 1914; 1920; Edgren 1984; Huurre 1998; Carpelan 1999; 2008). The mesh size of the net was about 6 cm, which is suitable for catching, e.g., bream or salmon (Pälsi 1914; Huurre 1998; Carpelan 2008). Jukka Pennanen (1987) argues that the Antrea net was actually a seine based on the thickness of the yarn. In my opinion, such a heavy net seems too heavy to carry or pull.

Some knots of the Antrea net have survived. Sakari Pälsi drew a picture of the knots in his original article of the find (Pälsi 1920). The knot type has commonly been called a "*ryssänsolmu"* ("Russian knot") (see Turner & van de Griend 1996; Huurre 2008). When I tried to find a correct translation in English for this knot type, I found out that no knot book mentions this kind of a knot. Instead I realized, that the Antrea net knot has exactly the same appearance as the sheet bend (*jalussolmu* in Finnish). I asked the Institute for the Languages of Finland (*Kotimaisten Kielten Keskus)* about the origin of the word *"ryssänsolmu"*, and the specialist Kirsti Aapala answered that according to the archives of the modern-day dictionary the word was added the dictionary specifically from the ethnographic literature of the early 20th century, especially from U.T. Sirelius´ book *Suomalaisten Kalastus* in 1906. The knot is still included in the Finnish Dictionaries published between 1951 and 1961, and is explained as a "single-stitched netting knot". Subsequent general dictionaries no longer contain the word, probably because people no longer wanted to use a word that starts with "ryssä"; it has been used as a term of abuse for Russians, and has thus gained a negative connotation (Aapala personal e-mails 10.6.2019 and 11.6.2019).

Sirelius' book contains three images of netting knots, which are no longer found under those names (in Finnish) in modern knot books: "*kypäräsolmu"* ("helmet knot"), "*köydensolmu"* ("rope knot") and "*ryssänsolmu"* (Sirelius 1906; 2009). "*Kypäräsolmu"* equates to the reef knot (*merimiessolmu* in Finnish) ("Gilcraft" 1929; Ropponen 1931; Wirkkala 1963; Snyder & Snyder 1974; Budworth 2012). "*Köydensolmu"* equates to the sheet bend, which is also the same as the weaver´s knot, a form of the sheet bend ("Gilcraft" 1929"; Budworth 2012). Sirelius mentions this knot as the best for netting (Sirelius 1906; 2009). The weaver´s knot is directly translated as *kutojansolmu* in Finnish, but in Martta Ropponen´s knot book (1931) *kutojansolmu* is different, and this kind of knot equated to a sheet bend is called "*kangassolmu"* ("fabric knot") or in other words "*kynsisolmu"* ("nail knot"). In Ilmari Wirkkala´s book (1963) the synonyms for the sheet bend are *"kynsisolmu"* and *"lippusolmu"* (flag knot), with no mentions of "*kangassolmu"* or *kutojansolmu* at all. Ropponen also writes: "The sheet bend (using the word *jalussolmu*) is also used in netting, which is better than a reef knot ("*kypäräsolmu"*) because it can withstand jerking in different directions without slipping" (Ropponen 1931). The modern Term Bank (TEPA) of the Finnish Terminology Centre (TSK) mentions *kutojansolmu* (weaver´s knot) as a synonym of *jalussolmu* (sheet bend). Martta Ropponen wrote in 1931 that "the names of the knots have caused difficulties because there are so few established Finnish names" (Ropponen 1931), which seems to be very true even today. Current Finnish knot books are translations from English books, and do not contain information about older Finnish knot names.

About the "*ryssänsolmu*", Sirelius says it has been known only in the eastern part of Finland, used in small-mesh seines, and it is practical because it is created by a single stitch, but disadvantageous because it pulls the net mesh into a crooked shape, and therefore is not suitable for gillnets (Sirelius 1906; 2009). In addition to Sirelius, T.I. Itkonen mentions that *"ryssänsolmu"* have been used in small-mesh gillnets and seines among the Sámi (Itkonen 1984). Older Finnish knot books (e.g., Ropponen 1931; Wirkkala 1963) do not know *"ryssänsolmu*" at all. If you look closely at the knots, you can see that *"ryssänsolmu"* is actually a mirror image of the sheet bend or weaver´s knot.

The executive director of the Fisheries Museum Association (*Kalastusmuseoyhdistys ry*), Ari Lappalainen, writes that in earlier sources the Antrea net knot has been mistakenly referred to as a *"ryssänsolmu"*, even though it is actually a *"köydensolmu"* (Lappalainen 2004). The picture of the Antrea net knot in the original article (Pälsi 1920) is indeed identical to the picture of a *"köydensolmu"* in Sirelius´ book (1906; 2009). When it comes to the name of the knot, Pälsi´s original article (1920) does not actually mention it at all. Instead, Pälsi writes in his popular newspaper article (Pälsi 1914), published right after the actual find: "the knots are *"aunukselaisia ristisolmuja"* ("cross knots from Aunus", Aunus is a city in Russian Karelia) and the same ones that are introduced again in machine-woven nets" (my translation). In fact, the only archaeological reference I found that mentions the Antrea net knot as a *"ryssänsolmu"* is the book "Kivikauden Suomi" by Matti Huurre in 1998. None of the other archaeological books or articles that I have read concerning the Antrea net find mentions the name of the knot. The big book "Fish Catching Methods of the World" by Anders von Brandt (1984) name the Antrea net knot as the weaver knot (no genitive). But somehow the name "Russian knot" appears in the scientific book "History and Science of Knots" (Turner & van de Griend 1996) in connection with the Antrea net, and the source mentioned is Pälsi´s article of 1920, where the name of the knot does not appear. It is unclear where the incorrect knot name is left in certain texts for life.

Modern Finnish fishermen's netting instruction books say that the sheet bend (using the Finnish word *jalussolmu*) with its variations is the basic knot in netting (Heikkilä P. 1989; 2007; 2008). There is even a picture of both a right-handed sheet bend (looks to the same as Sirelius´ "*köydensolmu"*) and its mirror image the left-handed sheet bend (looks the same as Sirelius´ "*ryssänsolmu"*) (Heikkilä P. 2007; 2008). Snyder & Snyder (1970) represents the basic marine sheet bend as Sirelius' *"ryssänsolmu"*, meaning "left-handed" according to Pekka Heikkilä (2007; 2008). The same kind of fish netting knot has been used as far away as among pre-European Māori in New Zealand (Leach 2006). Leach (2006) mentions this knot having several names: the weaver knot (no genitive), the trawlers knot, the sheet bend and the netting knot. In any case, the weaver´s knot or sheet bend seems to have long been universal in netting. According to Anders von Brandt, this knot has been used in Northern Europe at least since the Stone Age and among the natives in North America before the day of Columbus, and it is nowadays the most widely used knot in European and American fisheries (von Brandt 1984).

In today's vocabulary, the sheet bend is usually associated with nautical terms. As a result of all this, I suggest that from now on the Antrea net knot should be called a weaver´s knot, *kutojansolmu* in Finnish (which is the same as the sheet bend, *jalussolmu* in Finnish). This would serve both clarity and linguistic consistency.

Figure 8. Net sinkers, KM 7965:6 found at Kangasala Apajanpohja. Height 106 mm, width 124 mm, thickness 24 mm. Photo: Esa Suominen, Finnish Heritage Agency (https://finna.fi).

5.1.2 Other nets

In addition to the Antrea net, other evidence of net fishing consists of an abundance of net sinkers made of stone found in Stone Age contexts up to the southern Lapland, and especially on the south coast (Minkkinen 1999; 2000). Particularly fine and well-preserved net sinkers (Figure 8) have been found at Kangasala Apajanpohja (Huurre 1998).

Some other commonly known finds related to fishing nets include a net impression of weaver´s knots/sheet bends in ceramics from Kiukainen Uotinmäki, a fishing net shuttle (*verkon käpy* in Finnish) made of bone from Åland, and bark rollers possibly used as floats from Humppila Järvensuo (Huurre 1998). A little later, from the early metal period, there is a possible seal net from Pori Tuorsniemi (Finnish Heritage Agency).

5.1.3 Stationary wooden fishing structures

The remains of a stationary wooden fishing structure, a fish weir, at Yli-Ii Purkajasuo in northern Ostrobothnia, north-western Finland, have been studied recently (Koivisto 2012; Koivisto & Nurminen 2015; Koivisto 2017). The weir was used between circa 3500 and 2900 calBCE, when the area was the Iijoki river estuary (Schulz H-P 1997; 1998; Koivisto 2012; Koivisto & Nurminen 2015; Koivisto 2017). It has been preserved in a wetland context and shows the great importance of fishing among the occupants of the site. Another wetland wooden fishing structure at Kurikka Hiipakanluhta in southern Ostrobothnia has been radiocarbon-dated to the Stone Age (Koivisto 2012), and there will certainly be more fishing tackle preserved at wetland sites whose research is just beginning.

5.1.4 Angling hooks, gorges, and line weights

Hook and line are typical Stone Age fishing gear in Finland. Many hooks are made of stone and some of bone (e.g., Leskinen 2002). Parts of hooks and line weights made of stone have been found in Stone Age contexts from the Early Mesolithic all over the country (e.g., Schulz H-P 1996; Edgren 1967; Rankama 1996; 1997; Minkkinen 1999; 2000; Naskali 2004). In the Stone Age, the hook may have been made of stone, wood, or bone, or a combination of these. An especially interesting hook model is an example made of the worked dentales of a pike, such as have been found within a late Neolithic context in Switzerland. In those hooks, parts of the dentale and most of the teeth were carved out, so that one or two of the largest front teeth were left as a point (Choyke & Bartosiewicz 1994). Such a hook could be used inside the bait fish or tied to the bait belly. If fishing gear made of bone had survived in Finnish soil, we could have a diverse selection of different fishing gear in Finland as well.

The use of hook and line is an active fishing method, while a simple, common passive fishing method is the use of a double-pointed gorge (two-barbed hook or point). These gorges are usually made of bone, wood, or antler. There are only a few double-pointed gorges made of stone found in Finland, the best known of which is the one made of slate found at Viipuri Häyrynmäki (in Southern Karelia, the area belonging to Russia today). This artefact is considered to be Middle Neolithic in date (Edgren 1984; Naskali 2004).

Several of the stone line weights (Figure 9) have been polished in the shape of a fish. The most beautifully made are the so-called B2-type line weights, of which 19 have been found in Finnish Stone Age contexts. The most skilfully made of these is a perfect fish-shape weight found in the Neolithic site of Leppävirta (KM 17076:49), made of Onega green stone (Naskali

2004). Fish-shape line weights have grooves and/or a hole for hook and line, and are thought to have worked like a winter jig, jerked up and down through a hole in the ice (Edgren 1967; Naskali 2004), and therefore suggest winter fishing.

One question is, then: what is the real purpose of these finely polished stone line weights? Stone Age hooks were so heavy and robust compared to modern worm/larva fishing hooks that they most likely required small bait fish to catch bigger fish. Bait fish by themselves are enough to attract predatory fish to a place; no fish-shaped line weight is needed for this purpose. Rougher weights, which have also been found in Stone Age contexts, keep the line and hook under water as well, so why spend time polishing the line weight stone? If the line breaks, the line weight will sink to the bottom and disappear. Of course, it is possible that thin hooks made of wood or bone with a worm or larva as bait would have been used with the stone weights. Some types of stones can potentially reflect sunlight when polished in an interesting way to attract fish, and it might work on a sunny day. Fish-shaped lures are often combined with winter fishing, and today ice anglers use metal fish-shaped lures under the ice with a bait worm or larva. Some metals perform better than others; an old fisherman told me of a young-herring-coloured lure (old herrings do not have the same hue) that works best for perch in the winter. Under the ice it is darker than in open water, and stones, even if polished, are much dimmer than metal - so could a stone line weight really work as a fish attractor under the ice?

Fish-shaped fishing equipment is also found elsewhere in the north, for example in the Western Thule culture in Alaska, from 950 to 1400 CE, when the Eskimos in Cape Krusenstern (Alaska) had gorgeous fish-shaped lures made of (caribou?) antler and (walrus?) ivory (Giddings & Anderson 1986). Many of these lures have small holes for hooks and could have also been used for trolling, which means that the fishing method has been different, and the materials, antler and tusk, are much easier to carve than stone is to polish. In Finland, only a few pieces of fishing gear made of bone or antler have survived (e.g., Leskinen 2002), so we will probably never know how diverse the fishing gear may have been during the Stone Age. However, when it comes to stone fishing gear, even the net sinkers of the famous Antrea net were rough ordinary stones (Pälsi 1914; 1920), as probably most everyday line weights were. Perhaps these fine artefacts were works of a Stone Age visual artist and meant for display, or served as amulets for a good catch.

Figure 9. Stone Age polished line weights. Right: Neolithic fish-shape weight, KM 17076:49, height 61 mm, width 18mm, thickness 5 mm, made of Onega green stone found at Leppävirta. Photo: Markku Haverinen, Finnish Heritage Agency (https://finna.fi).

5.1.5 Other fishing gear

Ice picks (Figure 10) from the Stone Age are supposed to indicate winter fishing (Lappalainen & Naskali 1999). A bone ice pick made of an elk metacarpus has been found in Kirkkonummi (Äyräpää 1950; Edgren 1984). Clay stuck to this ice pick has been found to be from the Ancylus Lake (Edgren 1984), which dates the ice pick to the Mesolithic. The Kirkkonummi ice pick is, along with the Antrea net, one of the oldest archaeological finds in Finland. Similar Mesolithic ice picks, as well as other fishing gear artefacts similar to those discovered in Finland have also been found in the Volga and Oka rivers in Russia (Zhilin 2014) - the area where the ancestors of the post-glacial inhabitants of present-day Finland originated. These finds indicate that fishing was an important activity already for early immigrants. Stone Age ice picks made of stone have been found in many places in Finland, with varying degrees of polishing (Finnish Heritage Agency).

Figure 10. Ice pick made of bone. Reconstruction made by Risto Järvisalo. Photo: Katariina Nurminen

We also cannot forget about the numerous projectile points made of stone which were probably used for hunting but are also suitable as fishing gear. No leister prongs have been found in Stone Age contexts in Finland, but they would have probably been made of bone or wood, and therefore would not have been preserved until our times. Many fish, such as pike, could also have been bludgeoned to death with a stone club (see 4 *Ethnographic background, 4.2.1 Club fishing, spearing, and looping*), such as those found in Stone Age contexts (e.g., Äyräpää 1950; Schulz H-P 1996). A stone club with a groove, such as the three examples found in the Utsjoki Onnela site in northern Finnish Lapland (Rankama 1986; 1987), would be perfect for bludgeoning a large (predator) fish.

There are also a few remains of a Neolithic fish trap (KM 11645:2, Figure 11) made of soft willow branches from Köyliö (Huurre 1998). Even from such small remnants it can be seen that the traps (Figure 12) were made with skill already during the Stone Age.

Some depictions of fish, resembling pikes, have also been identified in Stone Age rock paintings in Finland. There is an example from Juusjärvi, Kirkkonummi depicting a fish and a human (Kivikäs 1997; 2000). In Kapasaari Vuohijärvi, Jaala, there are four small and partly broken fish paintings (Kivikäs 1997).

Figure 11. Remnants of a Neolithic fish trap, KM 11645:2 made of soft willow branches at Köyliö. Photo: E. Laakso, Finnish Heritage Agency (https://finna.fi).

Figure 12. Reconstruction of a fish trap for small fish individuals/ species, built by Risto Järvisalo. Photo: Katariina Nurminen

5.2 Stone Age fish bones in Finland

Burned fish bones are frequently discovered in excavations of Stone Age settlements in Finland. Fish bones are often found in and near hearths within prehistoric settlements. The bones were likely burned in connection with cooking or meal preparation, when the excess bones would have been thrown into the fire. Bones are also found in garbage pits, or in other large concentrations in which they were collected specifically as waste.

In earlier years, when excavation finds were not always screened, or were screened with a large mesh size, only some bigger pike bones, especially bones of the lower jaw (dentalia, Figure 13), were recovered from Finnish archaeological sites. Older excavation methods did not favour the recovery of small fish bones. Burned fish bones may not have been seen as important, and were usually thrown into the spoil heap.

Figure 13. Dentale (length 6,5 cm) of a modern reference pike (top) with four burned fragments (KM 33923:9209 and KM 33923:9229) from the Neolithic site of Joroinen Kanava. Photo: Markku Haverinen, Finnish Heritage Agency

This led easily to conclusions of pike being the most important fish in prehistory. Finns have a special national romantic bond with pike, starting from the national epic the Kalevala, which relates the myth that old Väinämöinen carved a traditional Finnish harp (*kantele* in Finnish) out of the jawbone of a large pike. The pike is a predatory fish with a lot of teeth, and it can grow quite large (record catch in Finland since 2000: 18.8 kg; https://www.fishinginfinland.fi/pike). This makes it somewhat notorious, including stories where pikes have bitten people, as can be read from time to time in newspapers. The pike will always have a special position in the minds of the Finns, which may have contributed to its place in Finnish archaeological literature.

Fish bone finds in Finland have not been studied thoroughly before my work on the subject (Nurminen 2004a; 2006; 2007). The reasons for this have been the absence of osteologists, especially ones familiar with fish bones, as well as the lack of sufficient reference collections (see *6.2.1 Identification of bones*). Burned bones have been identified only since the 1970s and more carefully since the 1990s. Fish bones have been studied within the framework of general osteological analyses from prehistoric sites, but fish vertebrae were rarely identified before the beginning of the 2000s. Most Finnish osteological analyses are unpublished reports in the archives of the Finnish Heritage Agency in Helsinki. Here I will briefly outline the main features of the fish bone finds pre-dating my current research (Table 1). The results of my current study are presented in chapter *8 Fish bone analyses from Stone Age sites*.

Stone Age fish finds in sites throughout Finland so far consist mainly of freshwater fish (Nurminen 2006; 2007; Finnish Heritage Agency osteological reports). All of the Stone Age sites in Finland for which I have identified fish bones before or outside of this study are presented in Table 1. The skeletal structure of the fish is presented in chapter *6.1 Skeleton of a fish*. As mentioned before, the most common species identified at Stone Age sites during the past decades is pike. The overrepresentation of this large species was due to the lack of sieving. The pike bones found are mostly parts of the hard bones of the viscerocranium and zonoskeleton anterior in the head, mostly the dentale (part of the composite jawbone) and palatinum (the robust palate of pike equipped with numerous teeth). These bones are usually preserved even when the rest of the bone material is almost completely destroyed. In addition to dentale and palatinum, the articulare (also part of the lower jaw), quadratum, and vomer of pike are relatively well preserved. The thick middle parts of the parasphenoideum and cleithrum are also often preserved even when burned, but the thick proximal tips of the cleithrum are usually destroyed by burning. Pike vertebrae are rarely found but usually occur in large samples from contexts where there are plenty of other fish remains.

Perch and cyprinids, such as roach, bream, rudd and ide, are common among Stone Age fish finds in Finland (Nurminen 2006; 2007; Finnish Heritage Agency osteological reports). For both perch and cyprinids, all skeletal elements are well represented. The most commonly preserved

SITE	INV. NR	PERIOD	EXCAVATION/SURVEY	Esox l.	Sander l.	Perca f.	Cyprinidae	Coregonus l.	Salmonidae*	Lota l.	Others
Lieto Knaapin hiekkakuoppa	KM 34049	M	Päivi Kankkunen 2003				1				
Ruokolahti Torsanpää	KM 41100	M	Jan-Erik Nyman 2016	7			49				
Vantaa Hommas	KM 36869	M	Satu Koivisto 2007	3							
Vantaa Brunaberget	KM 39236	LM	Petri Halinen 2012	1			2				
Keitele Maaherranniemi	KM 41305	LM -MN	Jan-Erik Nyman 2017	16		1	5				
Keitele Maaherranniemi	KM 41575	LM -MN	Jan-Erik Nyman 2018	249	1	30	38				
Kotka Peippola	KM 37250	EN	Taisto Karjalainen 2007	63	1	21	9		1		
Ranua Mattila	KM 40529	EN	Jan-Erik Nyman 2015	73		1	15				
Eura Honkilahti Munasaari	KM 34051	EN - MN	Päivi Kankkunen 2003	1							
Eura Honkilahti Munasaari	KM 34737	EN - MN	Päivi Kankkunen 2004	1							
Padasjoki Leirintäalue	KM 33578	EN	Nina Strandberg 2002	38		17	10			3	
Padasjoki Leirintäalue	KM 39512	EN	Paula Kouki 2013	11		1	1			3	
Eno Saunalahti	KM 36720	N	Petro Pesonen 2007	5			2				
Rääkkylä Kotilansalo	KM 33377	N	Päivi Kankkunen 2002	12		1	2				
Rääkkylä Kotilansalo	KM 34024	N	Päivi Kankkunen 2003	66	2	11	15				
Joroinen Kanava	KM 33923	MN	Eeva-Liisa Schulz 2003	3493	21	1219	1841	1	10	16	wels 3
Raahe Kauniinmetsänniitty 1	KM 36937	MN	Petro Pesonen 2007	4		1	3		4		
Rantasalmi Rantakartano	KM 31643	MN	Päivi Kankkunen 1999	1							
Rantasalmi Rantakartano	KM 32469	MN	Päivi Kankkunen 2000	2	1		1				
Saarijärvi Uimaranta	KM 33321	MN	Sirpa Leskinen 2002	477	2	47	110	1	4	1	
Hamina Viidankangas	KM 41009	MN - LN	Paula Kouki 2016	2		1					
Hamina Viidankangas	KM 41638	MN - LN	Niko Anttiroiko 2019	66		27	46				
Kokkola Pahanportaanräme	KM 33928	MN - LN	Lauri Skantsi 2003	1							
Savonlinna Kerimäki Martin-niemi	KM 31514	MN - LN	Petri Halinen 1998	216	14	13	157	3	2	2	salmon 1, wels 1

Mäntyharju Muurahaisniemi	KM 36702	MN + EMP	Petro Pesonen 2007	1827		11	192				
Harjavalta Kraakanmäki 1	KM 40296	LN	Petro Pesonen 2014	17		10	12		7		
Harjavalta Kraakanmäki 2	KM 39895	LN	Petro Pesonen 2014	8		1	2				
Kaustinen Koppelonharju	KM 40966	LN	Jan-Erik Nyman 2016	5		1	2	1			
Oulu Hangaskangas E	KM 40359	LN	Esa Mikkola 2014	4		3	5	11	11		
Polvijärvi Pohjanperänkangas	KM 36742	LN	Petro Pesonen 2007	19		2	7	1			
Rovaniemi Koskenniska	KM 39172	LN	Satu Koivisto 2012	2		1	3	2	4		grayling 1
Rovaniemi Koskenniska	KM 39632	LN	Petro Pesonen 2013	389		14	23	151	68	3	grayling 3
Kirkkonummi Pappila	KM 39296	LN - EMP	Petro Pesonen 2012	7			1				
Haukipudas Hiidenkangas	KM 37290	?	Johanna Seppä 2007	8		1	1				
Kannus Kivineva	KM 41626	?	Lauri Skantsi 2018	4		1	3	1	2		
Nilsiä Metsäharju	KM 37137	?	Petro Pesonen 2006				1				
Nilsiä Vellijärvi	KM 37130	?	Petro Pesonen 2006	1							

Table 1. Stone Age sites in Finland, from which I have identified fish bones, previous to or outside of this study. The osteologist at all the sites was the author. NISP of fragments identifiable by family/ species.
Periods: M = Mesolithic, LM = Late Mesolithic, N = Neolithic, EN = Early Neolithic, MN= Middle Neolithic, LN = Late Neolithic, EMP = Early Metal Period.
*Salmonidae = Salmonid vertebra fragments unidentifiable by species (salmon, trout, whitefish, grayling etc.)

bones of perch are the dentale, articulare, quadratum, praemaxillare, maxillare, praeoperculare, and vertebrae. The larger percid species, pikeperch, also occurs regularly but is relatively scarce. Mainly dentales, and some other bones of larger pikeperches, have been identified. The third percid species known in Finland, ruff, is totally absent from the archaeological context.

Cyprinid bones can be usually identified on the family level. Species can be identified using a few diagnostic elements, for example, by the commonly preserved pharyngeal bones *(ossa pharyngea inferiora)* behind the gills, where the teeth break the food against the keratinous plate on the roof of the pharynx. The dentalia of cyprinids have no teeth. In addition to the pharyngeal bones, cyprinid vertebrae preserve well. Many other bones, such as keratohyale, hyomandibulare, maxillare, frontale, scapula, and some thick rib (costa), fin bone (lepidotrichia) and pterygiophora proximal heads are often found. Overall, the thickest parts of bones, such as the articular surfaces, preserve best in the burned assemblages. It should be noted, that the articular surfaces of identifiable operculare (Radu 2005) are regularly found, but they are fragmented and unidentifiable to species due to burning.

The only salmonid fish commonly found at Stone Age sites in Finland is whitefish (Nurminen 2006; 2007; Finnish Heritage Agency osteological reports). Almost all the whitefish bones are vertebrae, which seem to preserve quite well in Finland. The head bones of the whitefish are very thin, and brittle compared to the head bones of pike, perch, and cyprinids, so it is very rare to have such bones survive after the burning process.

Burbot is a rarely occurring species, yet it has also been found throughout Finland. Most of the preserved burbot bones are vertebrae, although some head bones have also been found. Burbot finds seem to be related to winter fishing during its spawning time in January and February (see *9.1 case study1: Burbot bones and winter fishing*).

Bones of different fish species are preserved in different ways. The most fragile and greasy bone parts are destroyed already during burning, and as a result much of the skeleton disappeared already in the Stone Age. In order to better understand this process, I carried out burning tests with fish bones (Nurminen 2016), which are described in chapter *7.1 Taphonomy of burned fish bones*. I have also studied the effect of screening and screen size on the recovery and identification of fish bones in chapter *7.2 Excavation methods and sieving the small fish bones*.

5.3 Rare fish species in archaeological bone assemblages from Finland

As described in the chapter above, typical freshwater fish species such as pike, perch, cyprinids, and whitefish have been widely found in Stone Age contexts so far, as well as pikeperch and burbot, which are regularly occurring though scarce. In addition, there are some rare fish bone finds from sites not discussed in this study, which I will present here.

Among the salmonids, in addition to the abundance of whitefish, I have found only a couple of salmon (Koivisto & Nurminen 2015) and grayling (Nurminen 2012a; 2014) vertebrae in the Stone Age material in Finland. Graylings are known from the late Neolithic, calBCE 2920-2690 (Pesonen 2013; Possnert 2014), site of Rovaniemi Koskenniska, Lapland. In comparison with skeletal elements from other fish families, salmonid bones are greasy, poorly ossified, and fragile, and therefore are destroyed rapidly, especially when burned. Still, salmonid vertebrae preserve better than the head bones (Lubinski 1996).

Only recently I found the first Stone Age trout bones from Finland, at the site of Savukoski Sokli in eastern Lapland. These burned bones are exceptionally well preserved, including not only vertebrae but also fragile head bones such as the dentale, articulare, quadratum, and praeoperculare (Nurminen 2020). The Finnish Heritage Agency´s investigations in Sokli are still ongoing, and dating and other results will be published later.

Only a handful of marine fish bone fragments have been found in Stone Age sites in present-day Finland. A few fragments of cod were identified

Figure 14. Wels costae, KM 33923:8663 and probable wels vertebrae, KM 33923:9120 and :9122 with modern comparative bones. The reference fish, aged 5+, weighted 2,8 kg at the time of catch. Top left: costae. Top middle and right: fragments of large, more than 3 cm in diameter, vertebrae. In the bottom row, modern reference specimens (diameter of vertebra corpus is 1 cm) are shown below the archaeological fragments. Photo: Ilmari Nurminen

at two Baltic seashore sites, Kemiö Branten and Eurajoki Etukämppä (Ukkonen 1997; 2004a). Both sites are dated to the late Neolithic, on the basis of shore displacement at Kemiö Branten in southern Finland (Asplund 1992), and at Eurajoki Etukämppä in south-western Finland based on ceramics (Lehtonen K. 2003).

One dentale and nine vertebrae fragments of eel, as well as a possible dentale of four-horned sculpin, have been found at Räisälä Juoksemajärvi Westend (Halinen et al. 2008; Seitsonen 2010), a former Finnish municipality in the area of southern Karelia between the eastern Baltic and Lake Ladoga, now belonging to the Russian Federation. Räisälä Juoksemajärvi Westend was a long-term Stone Age site inhabited from the Mesolithic to the late Neolithic (Halinen et al. 2008). Nine of the eel bones and the Cottidae dentale were found in a Neolithic context, and one eel bone in a Mesolithic context (Halinen et al. 2008). Eels, as well as flounders and turbots, have greasy bones prone to decay. Flounder and turbot are absent the Stone Age refuse bone materials in Finland.

Wels, a mystical fish of the old tales, is now extinct in Finland. I have identified a fragment of a wels praemaxillare at Kerimäki Raikuu Martinniemi (Nurminen 2004b; 2006), dated to the late Neolithic based on ceramics (Halinen 1998) and three proximal heads of wels ribs (costae) with small fragments of huge, more than 3 cm in diameter, vertebrae probably of wels (Figure 14) at Joroinen Kanava (Nurminen 2003a; 2006). The fish bones at Joroinen Kanava are dated to the Middle Neolithic, calBCE 3799-3626 (Schulz E-L 2004; Jungner 2004; OxCal 4.3; Bronk Ramsey 2009).

6 Materials and methods

The material assemblage of this study consists of burned fish bones found in Stone Age sites in Finland. In this chapter, I present the basics of the fish skeleton, the challenges of identifying burned fish bones in general, the methods used in identification, and the sites chosen for the study.

6.1 The skeleton of a fish

The fish skeleton (Figure 15) can basically be divided into two main parts, the head skeleton and the vertebral column with appendages (Casteel 1976, Wheeler & Jones 1989). Those familiar with the elements of the general mammalian skeleton will notice that the internal skeleton of bony (teleost) fishes is far more differentiated. Here I will briefly describe the most important parts of the skeleton used in zooarchaeological identification, especially for those readers who are unfamiliar with these bones. The names of the most important elements are also given in Finnish to avoid ambiguity.

The fish skeleton comprises the axial skeleton, including the neurocranium, viscerocranium, and spine (with ribs and fin rays), and the appendicular skeleton (Lepiksaar 1981, 1983). As shown by its name, the appendicular skeleton includes bones that do not belong to the skull in an evolutionary sense, although they are directly adjacent to the head and are called as such in vernacular language. In this study, when referring to the head bones (see also Wheeler & Jones 1989:87), all skeletal elements associated with the head are included. The fish "head" in this broad sense thus consists of several parts:

Neurocranium, which are the bones that surround and protect the brain. The bones of the neurocranium do not usually preserve when burned, except for the *frontale* (*otsaluu* in Finnish*)* and *parietale* (*päälaenluu* in Finnish) of some species.

Viscerocranium (Figure 16), which are bones involved in the ingestion of food (e.g., composite "jaws") and parts of the gill arches (*operculare* = *kiduskannen luu* in Finnish), and thirdly, the bones forming the throat (e.g., hyal bones). Many bones of the viscerocranium often remain identifiable even after burning.

Zonoskeleton anterius, the bones supporting the pectoral fins, of the appendicular skeleton. In archaeological assemblages the most important bone of the zonoskeleton anterius, the large *cleithrum* (*hartian lukkoluu* in Finnish) that tends to be preserved and identifiable in some species even after burning, is closely linked to the head.

The *basipterygium* (the bone supporting the pelvic fins) of the appendicular skeleton is not adjacent to the head (Wheeler & Jones 1989; Radu 2005) and is therefore not included with the head bones.

In addition to cranium, the axial skeleton also includes the series of *vertebrae* forming the vertebral column. The dorsal and anal fins are attached to the vertebral column through *pterygiophorae*. In addition, the fish skeleton includes ribs (*costae*) and fin rays (*lepidotrichiae*). The vertebrae are usually well preserved when burned, and the proximal articular ends of ribs and fins can often be identified.

In addition to this basic division, many fish have family-specific bones. Of these, pharyngeal bones with teeth in the viscerocranium of cyprinid fish are the most significant from the zooarchaeological point of view.

The jawbone (*mandibula*, *leukaluu* in Finnish) of mammals is a single bone, but in fish the composite jawbone consists of three different bones: the *dentale* (see also *5.2 Stone Age fish bones in Finland*), *articulare*, and *angulare* (Figure 16). The upper jaw of a fish has two bones: the *praemaxillare* and *maxillare* (*yläleuanluu* in Finnish). The robust palate (palatinum, *kitaluu* in Finnish) is linked to the upper jaw (Figure 16). In some fish species, e.g., pike, it is equipped with numerous teeth.

In addition to bones, the otoliths (ear-stones dealing with balance and hearing in the inner

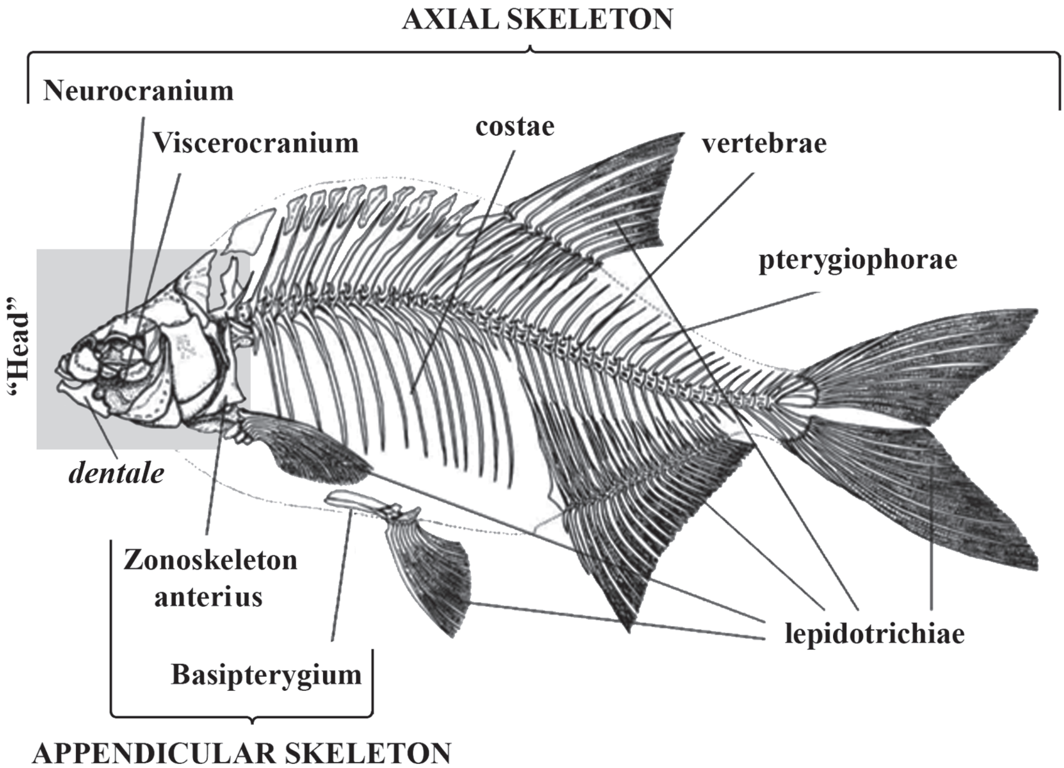


Figure 15. Skeleton of a bream *(Abramis brama).* Original figure (Radu 2005) edited by Ilmari Nurminen.

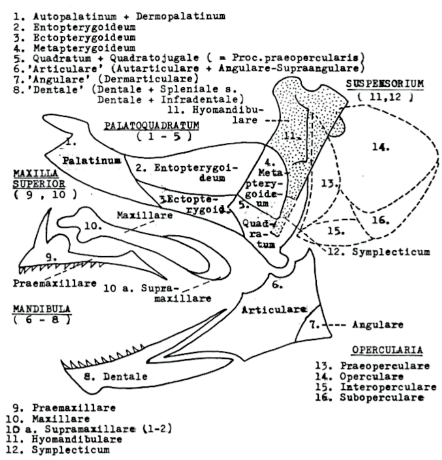


Figure 16. Bones of a fish viscerocranium (Lepiksaar 1981, 1983).

ears of fishes, *tasapainokivet* or *kuulokivet* in Finnish) and scales are important in fish identification and age-determination in non-burned assemblages (Wheeler & Jones 1989). Otoliths are formed from calcium-carbonate (Wheeler & Jones 1898) and scales are rigid plates of the dermis (Raitaniemi et al. 2000). Neither of these is usually preserved in burned materials.

6.2 Burned bones as research material

Research on burned bones is rare throughout the international research literature. Osteological analyses of fish bone remains usually consist of identification of species, quantification of bones and estimation of size and weight of the fish. Besides this, the age and growth of the fish as well as the season of capture can be examined (Casteel 1976; Wheeler & Jones 1989; Olson 2008; Boethius 2018). When it comes to burned bones, almost every morphological feature is crushed during the burning process. However, burned bones can be identified and quantified always considering the taphonomical circumstances when dealing with results. Burned bones do not allow the use of now common stable isotope studies due to the deterioration of bone collagen. As a new research method, ancient DNA research of bones has grown rapidly in recent years, but isolating DNA from burned bone is impossible, or at least very challenging (Ottoni et al. 2009; Tourunen & Niemi 2010).

Burned bone refuse is mostly recorded as unidentifiable fragments. Only less than 10%, and in the case of fish bones usually less than 5%, of the bone finds can usually be identified to the level of specific bone, and the majority of these are small fragments of vertebrae, ribs, and fins, which are not identifiable even to the level of family. After this taphonomical loss, only a very small percentage of the original recovered bones can be identified to the level of family or species.

In Finland, all surviving fish bone finds from the Stone Age are small, burned crumbs, mainly joint surfaces and other thick skeleton parts. Complete vertebrae have also been preserved. Neither scales nor otoliths have been preserved in the prehistoric fish refuse bone assemblages. Besides being broken into small pieces and the more brittle bones being completely destroyed already when thrown into the fire some thousands of years ago, bones also shrink during burning (Ukkonen 1996a). In addition, the soft outer layer of the vertebrae wears off during burning. In this state, it is almost impossible to say anything specific about the size and weight of the fish – except whether it was “small” or “large”. Determining the growth of the fish and the season of capture seem almost like science fiction when working with burned bones. Many questions will be answered only by speculation.

However, burned bones still give us answers about the taxonomy and cultural roles of the fish, which make burned fish bones a useful source of information in the research of Stone Age fishing and environmental conditions. For the purposes of clarification related to the associated taphonomical problems, I have made burning and screening experiments with the fish bones; more on this in Chapter 7 *Taphonomical studies*.

6.2.1 Identification of bones

I have analysed and identified all of the fish bones in my studies in the Finnish Museum of Natural History LUOMUS. When I started my studies in the beginning on 2000s, the bone reference collection of LUOMUS consisted of only a few fish specimens (one of each): a small pike, perch, pikeperch, cod, bream, and some parts of burbot and a small salmon. These fish skeletons had been prepared in the beginning of 1960s, and many bones had gone missing over the decades. It would have been impossible to study fish bones with such comparative skeletons. Therefore, I had to start from the very beginning by preparing my own reference collection. Fisheries biologist Jussi T. Pennanen from the former Finnish Game and Fisheries Research Institute (today the Natural Resources Institute Finland) donated most of the fish. I also bought some fish from markets or fished for them myself with the help of my sons. I have prepared a reference collection of about 40 different Finnish fish species and all together around 100 specimens. Today, this collection is a part of the reference collection of LUOMUS for all researchers to use.

Unfortunately, the museum LUOMUS has neither an actual laboratory, nor proper modern tools such as good microscopes, let alone advanced equipment for bone analysis. Osteological analyses are such a new thing in Finland that the work has traditionally been done with the naked eye and a magnifying glass.

The archaeological bone fragments were analysed morphologically by comparing them with modern reference bones. Johannes Lepiksaar´s bone guide (Lepiksaar 1981, 1983) was used in naming the different bone parts. The author carried out the majority of the analyses, but some unpublished material was analysed previously by Dr Mikael Fortelius, Dr Pirkko Ukkonen, and Dr Kristiina Mannermaa, who have all given me their permissions to use these identifications in my studies.

Fish bones have been identified to the species level when possible, and if not, to the family level. For example, the bones of different species of Cyprinids are so similar that they are mainly identified by family. Only a few Cyprinids bones show distinct species-specific shapes, particularly when burned and broken into fragments. Similarly, small fragments of the vertebrae of salmonids are often difficult to identify with certainty as to the exact species, except for the vertebrae of whitefish, which has a clearer pattern of its own and is more apparent when burned.

The sides of paired bones, left or right, have been identified for the purpose of calculating the minimum number of individuals. I have specified the exact location of vertebrae only if they can be determined to have been the first or second precaudal vertebrae, and therefore useful in calculating the minimum number of individuals. Most of the burned vertebrae were recovered already broken into small pieces.

People commonly consider burned bones difficult to study and identify (e.g., Ukkonen 1996a; 2004). This might be so in comparison with unburned materials. You must know every curve of the bones being able to locate where each small fragment is originally from. Because there are no unburned fish bones in the Finnish Stone Age refuse material, I became used to analysing burned bones from the very beginning. Dr Pirkko Ukkonen, who introduced me with burned bones when I started my osteological career, taught me that the only way to really learn to know these bones is just to sit and stare at them from every direction for days, weeks, months, and years. That is what I did. In addition, the skeletal preparation of about a hundred fish specimens has taught me a great deal about bone shapes, species differences, and the location of bones in fish. Over the years I have learned to love burned bones and their mysteries, and it gives me an enormous satisfaction every time I solve the source of a small bone fragment whose identification looks impossible at first sight.

6.3 Sites with fish bones featured in this study

Most of the Stone Age sites in Finland that have burned bones among their excavated finds have fish bones. Fish bones were missing only in the earlier collections, when screening was not yet used on excavations or the bones were not recovered at all.

For this study, I have mainly selected sites with concentrations of burned fish bones, usually on a hearth bottom or in a waste pit. In most excavations over the decades, no bone concentrations have either been found - possibly due to the small size of the excavated area - or the small bones in the concentrated deposits have not been recovered for one reason or another. By choosing mainly bone concentrations as the material, the number of bones to be examined is much higher, which is both a qualitative and a quantitative advantage. This increases the reliability of the results.

The study includes a total of ten sites (Figure 17), of which five sites were inland during the Stone Age, located by a lake or river, and five were by the ancient Littorina Sea. Seven of the sites are in northern Finland, one in central and two on the southern coast.

The sites are dated both to the Mesolithic and the Neolithic (see chapter *8 Fish bone analyses from Stone Age sites*):

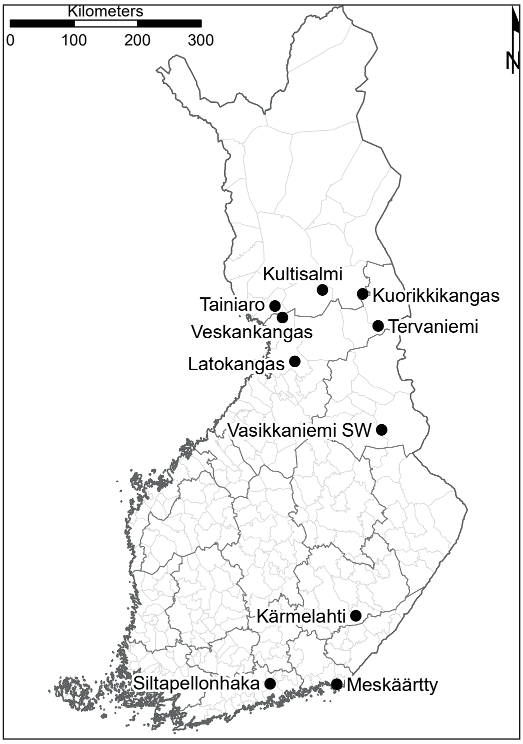


Figure 17. Sites with fish bones featured in this study. Materials: National Land Survey of Finland, Administrative borders 2019. Map: Perttu Strandman

Inland sites:

- Kuhmo Vasikkaniemi SW, Mesolithic
- Taivalkoski Tervaniemi, Mesolithic (/ Early Neolithic)
- Ranua Kultisalmi, Neolithic
- Posio Kuorikkikangas, Late Neolithic
- Puumala Kärmelahti, Late Neolithi

Littorina Sea coastal sites:

- Askola Siltapellonhaka, Middle Mesolithic
- Ii Kuivaniemi Veskankangas, Late Mesolithic
- Oulu Ylikiiminki Latokangas, Early Neolithic
- Simo Tainiaro, Early Neolithic
- Virolahti Meskäärtty, Late Middle and Early Late Neolithic

All of the inland sites included in this study have a fish concentration, as well as Oulu Ylikiiminki Latokangas and Virolahti Meskäärtty of Littorina coastal sites. The Askola Siltapellonhaka site was included in this study when I performed an osteological analysis of the bones from the site for the Finnish Heritage Agency, and I found the material to be well suited to the study. Ii Kuivaniemi Veskankangas and Simo Tainiaro were included in this study on the grounds that there were numerous fish bones recovered at each site, although no vertebrae had been identified at all. While analysing the bones of Ii Kuivaniemi Veskankangas, I also discovered that the majority were probably recovered from the bottom of a hearth.

7 Taphonomical studies

Taphonomy is the study of transition; the processes that leads human and animal remains to fossilization, and the stages of transformation of remains through the action of environmental factors (Efremov 1940). Zooarcheology studies taphonomic processes on animal remains. One of the most commonly studied process within zooarchaeology is thermal alteration (burning). Thermally altered bone indicate the use of fire and animal processing. The effects of erosion are also important for remains dating back thousands of years, such as Stone Age bones. In an archaeological context, human influence can also be significant. The way in which finds are recovered in excavations can produce different results and thus influence interpretations of the past.

Since the reliability of the information on burned fish bones is unclear, mainly due to problems related to taphonomy, I have included two specific empirical tests dealing with the research questions in this study: a burning experiment and a screening test. The bone burning experiment examines how much of the bone material is destroyed in the cooking processes before the bones are discarded as waste and buried. In the screening test, I study how the use of different sized screens affects the abundance of bones and the interpretation of fish species distribution. The use of these methods and an understanding of the effects of the taphonomy are essential for the interpretation of reliable results.

7.1 Taphonomy of burned fish bones

Taphonomy is an essential part of research based on burned bones. In addition to the bone loss resulting from exposure to acidic soil, burning also reduces the numbers of fragments that have been preserved since the Stone Age until today. However, as bone burns a hard outer crust is formed which enhances preservation (Gejvall 1969; Lyman 1994; Virkanen 2004).

As will become evident from this thesis, Stone Age fish finds in sites throughout Finland consist mainly of freshwater fish. The bones of various species of fish preserve in different ways. The pike bones that have been found are mostly parts of the hard head bones, such as the dentale and palatinum. These bones are usually preserved even when the rest of the bone material has been almost completely destroyed. Pike vertebrae are rarely found, but usually occur in contexts where there are plenty of other fish bone remains.

For both perch and cyprinids, all skeletal elements are well represented. Almost all the whitefish bones are vertebrae, which seem to preserve quite well. Other salmonid bones are very rare. Burbot is also a rare species in the Stone Age remains, yet still has been encountered throughout Finland.

7.1.1 Burning experiments

Burning destroys a large portion of the bones and makes analysis challenging. When arriving at conclusions, it is important to know what burning actually does to the bones. What proportion of the bones would have already been destroyed in the fire even before they ever got into the ground? I have studied the destruction of fish bones by grilling fish in an open fire and then throwing the bones into the fire, just as it was done in the Stone Age (Nurminen 2016).

For these burning experiments (Nurminen 2016) I used two pikes, six perches, ten roaches, three ides, one bream, and one whitefish. Trout was included in this experiment for the sake of comparison, because of the discussion concerning the lack of other salmonid fish besides whitefish in Finnish Stone Age fish remains.

For the actual burning, I first gutted the fish and then grilled them on the open fire with heads, scales, and fins still attached. After eating the flesh and throwing the skin and bones back into the fire, I let the fire go out slowly by itself. Then I sieved, counted, and identified what was left in

Figure 18. Identifiable pike bones after 2nd burning. Photo: Tero Nurminen

Figure 20. Identifiable big bream bones after 2nd burning. Photo: Tero Nurminen

Figure 19. Identifiable big perch bones after 2nd burning. Photo: Tero Nurminen

Figure 21. Identifiable smaller perch bones after 2nd burning. Photo: Tero Nurminen

the bottom of the grill. Burned bones from the Stone Age are often found on the bottom of a hearth, so the bones may have been there longer before the hearth had been cleaned. Therefore, I wanted to burn the same bones again to see the possible difference between the remains of a single meal and those that were longer at the bottom of the hearth. So, I burned all the identifiable bones a second time and sieved, counted and identified them again. I present here the conclusions to be considered when interpreting the results of burned bone analyses. The whole text of the article *Taphonomy of burned fish bones – burning experiments in the open fire*, with more specific details, is included as an appendix at the end of this book.

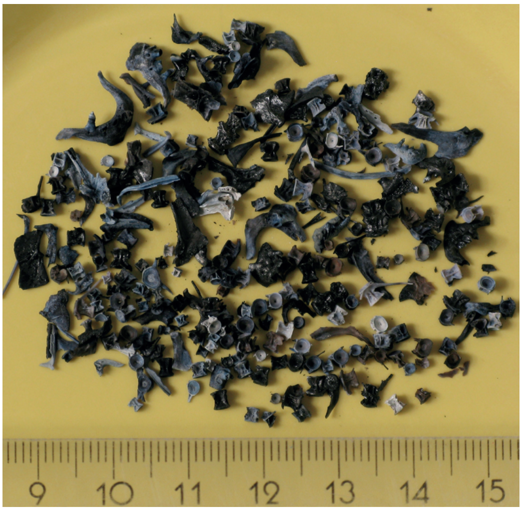


Figure 22. Identifiable smaller cyprinid bones after 2nd burning. Photo: Tero Nurminen

Figure 24. Identifiable trout bones after 2nd burning Photo: Tero Nurminen

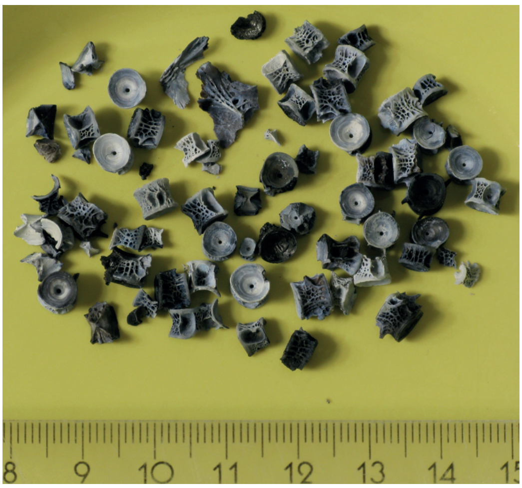


Figure 23. Identifiable whitefish bones after 2nd burning. Photo: Tero Nurminen

This experiment showed that when fish bones are exposed to an open fire, most of the bone loss already takes place during the initial burning. There is no big difference between burning the bones once or twice. The bones of the larger pike, perch, and bream (Figures 18, 19, and 20) survived better than the bones of smaller fish (Figures 21 and 22). The latter were lost in both burnings, but not significantly more so in the second burning. The first burning reduced the minimum number of individuals of perch, and the second burning reduced that of smaller cyprinids (roach and ide). As might be expected, smaller bones seem to be destroyed more easily than larger ones. This may be related to the greater relative surface of small bones that is exposed to the fire, which causes them to burn through more easily.

Fatty whitefish and trout head bones were destroyed almost totally after the two burnings. Nevertheless, the vertebrae of whitefish and trout survived equally well in this experiment (see Figures 23 and 24). The number of vertebrae in fish may vary between individuals. Trout are estimated to have 56-61 vertebrae (Kangur et al. 2003) and whitefish 58-65 (Sõrmus & Turovski 2003). Because the bones in the burning experiment were thrown into the fire as food waste, and therefore the vertebrae were not counted, I calculated trout and whitefish vertebrae from my own reference collections. The collections include two trout and three whitefish. One of the trout had 57 and the other had 59 vertebrae, and the number of whitefish vertebrae was 59, 60, and 62. In the burning experiment, after the two burnings, 43 complete, 12 half, and 8 smaller vertebrae fragments remained of the trout, and 42 whole, 11 half, and 18 smaller fragments remained of the whitefish. In both species, well over two-thirds of the vertebrae survived after two burnings. Therefore, the burning of bones cannot be the reason why there are so few salmon and trout bones in the Stone Age material.

The results of this experiment correspond to the fish remains found at Finnish Stone Age sites. It seems that most of the bone loss has happened already when the bones were burned, before being buried for thousands of years.

A specifically interesting question raised by this experiment concerns pike. Pike was well preserved in the burnings, and the surviving elements included both head bones and vertebrae. In Finnish Stone Age fish remains, however, pike vertebrae are quite rare, even though pike head bones are found in large numbers in sites throughout the country. What happened to the pike vertebrae? This may be related to the drying of fish, and will be discussed more in chapter *10.3.4 Drying of fish*.

7.2 Excavation methods and sieving for the small fish bones

Even very small fish bone fragments can provide essential information, provided of course those bones been recovered in the first place. Different screen sizes and screening methods for recovering burned animal bones in the field have been a subject of ongoing discussion between myself and the excavation staff ever since I started osteological analyses in 2001. Especially after specializing in fish bones and getting for analyses fish bone materials recovered in a number of different ways over the years, I have thought a lot about what kind of screening method would be best for the small fish fragments. Screens with large mesh sizes have also been used for fish bones in many excavations, and these are optimal for most other excavation finds. The overall mesh size has been 4 mm, but even larger sizes have been used. On this level, there is usually little to be identified in the small mammalian burned bone crumbs that are recovered. Excavations often have a tight and busy schedule, and it is clear that it is not always possible to spend time on the smallest details. Fish bones have not been a source of high interest to many field archaeologists.

There are some studies in the international literature with discussions on screening methods for bone recovery and mesh sizes (e.g., James 1997; Vale & Gargett 2002; Gobalet 2005; Zohar & Belmaker 2005; Partlow 2006). In Finland, Auli Bläuer (born Tourunen) has previously studied bone screening for creating historical data (Tourunen 2004). These studies cannot be applied directly to the screening of Finnish Stone Age fish bone materials, because they work with unburned bones.

In order to determine the optimal mesh size for burned fish bones, I took part in a Stone Age excavation in Vantaa, Finland, and recovered tens of bags of soil which I screened through different size meshes at the archaeology laboratory of the University of Helsinki. Unfortunately, very few bone fragments were found at that site, and those that were found were mainly of seal *(Phocidae)* bones. There were only a few fish bones, so my screening test failed at that time (Nurminen 2015a). Luckily, I then remembered the bones of the Stone Age site at Kuopio Nilsiä Lohilahti, which contained a large waste pit full of small fish bone fragments in addition to bones in cultural layers. The bones from the pit had not been sieved at all, but were stored along with the sandy soil. This bone material was an excellent choice for a screening test, as it was representative of a typical Stone Age species of bone refuse, in addition to which all the bones of the concentrated deposit have been recovered.

I had previously identified the Lohilahti fish bones for my master’s thesis (Nurminen 2002; 2004c; 2006). For this study, I decided to test different screen sizes for sieving large fish bone material from the Lohilahti waste pit. The results of the screening test were published in Finnish in the magazine *Muinaistutkija* (Nurminen 2015a), and I present them below with some supplementation.

7.2.1 Screening test

The Kuopio Nilsiä Lohilahti Stone Age site is located on the southern shore of Lake Syväri in eastern Finland. The area underwent a small excavation in 2002. There was a possible ancient fireplace and masses of small burned bone fragments in pit number 27. A carbon sample from charcoal was taken from the pit, with the resulting in a date of 3760±90 BP (Kankkunen 2002). The calibrated dating is 2461-1956 calBCE (OxCal 4.3; Bronk Ramsey 2009).

Large bags of sand abundant with tens of thousands of small bone fragments were collected from pit 27. Most of the bones were fish.

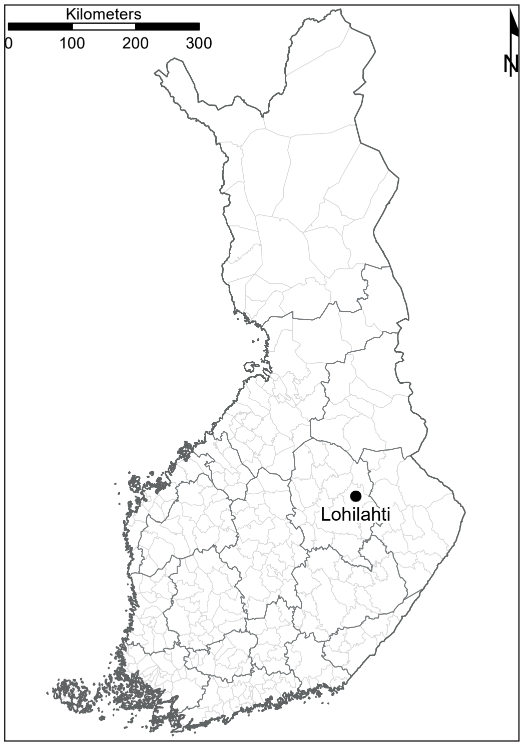


Figure 25. The location of the Kuopio Nilsiä Lohilahti site. Materials: National Land Survey of Finland, Administrative borders 2019. Map: Perttu Strandman

7.2.1.1 Osteological analysis of Kuopio Nilsiä Lohilahti

I had previously identified 14 567 fish bones from the Nilsiä (today belonging to the city of Kuopio) Lohilahti site (Figure 25), of which 2 779 were identifiable to the level of species or family (Nurminen 2002; 2004c; 2006). Most of the bones, however, were only identifiable as "fish". Since the identifications have not been published before, and this is a good example of what Finnish burned fish bone refuse can look like when a well-preserved waste pit is found, I include the total results of the osteological analyses of Lohilahti site here (Table 2, Nurminen 2002; 2004c; 2006). Note that the number of fragments represents only identified bones, that is, those that were identifiable by the exact bone, or a group of bones, such as vertebrae (but not necessarily species or family). For example, those identified by the term "Mammalia" or "Teleostei" may be a small piece of rib or vertebra not indicating the species or family. Bones burned or eroded into shapelessness have not been included in the total numbers found in Finnish bone analyses, as they account for 90-95% of all bone fragments and would flood percentage distributions. It is relatively common that the numbers of identified bone fragments of fish are many times larger than those of mammals, and birds are mostly rare.

SPECIES/ FAMILY	**FRAGMENTS**	**MNI**
Alces alces (elk)	8	1
Castor fiber (beaver)	23	3
Vulpes vulpes (fox)	2	1
Lepus timidus (mountain hare)	3	1
Martes martes (pine marten)	1	1
Mammalia (small vertebrae and costae fragments)	38	
Total mammals	**75**	
Tetrao tetrix (black grouse)	7	2
Lagopus lagopus (willow grouse)	6	1
Tetraonidae (grouses)	1	
Anatidae (ducks)	2	
Aves (unidentified birds)	20	
Total birds	**36**	
Esox lucius (pike)	1050	21
Sander lucioperca (pikeperch)	8	3
Perca fluviatilis (perch)	1000	49
Percidae (percids; pikeperch or perch)	25	
Lota lota (burbot)	19	1
Salmo salar (salmon)	1	1
Coregonus lavaretus (whitefish)	189	>1
Salmonidae (salmonids)	12	
Abramis brama (bream)	2	1
Leuciscus cephalus (chub)	4	1
Leuciscus idus (ide)	2	2
L. cephalus/ L. idus (chub/ ide)	2	
Rutilus rutilus (roach)	3	1
Cyprinidae (cyprinids)	462	
Teleostei (small fragments of fish vertebrae, ribs and fin rays unidentifiable to species or family)	11788	
Total fish	**14567**	

Table 2. Fish bones at the Kuopio Nilsiä Lohilahti Stone Age Site.

Fish species or family	Total identified bones in pit 27	Bones remained on 4 mm mesh	Bones remained on 2 mm mesh	Bones remained on 1 mm mesh
Pike	725 (441 skeletal part + 284 teeth dentes)	88 skeletal part	522 (352 skeletal part + 170 teeth)	1 angulare + 114 teeth
Pikeperch	5 skeletal part	1 skeletal part	4 skeletal part	-
Perch and percids	831 (789 skeletal part + 42 proximal heads of ribs costae)	52 skeletal part	766 (724 skeletal part + 42 proximal heads of ribs)	13 (head bones articulare, praemaxillare, maxillare, parasphenoideum)
Burbot	19 skeletal part	3 skeletal part	16 skeletal part	-
Whitefish	189 vertebrae	10 vertebrae	163 vertebrae	16 vertebrae
Salmon and salmonids	13 vertebrae, of which 1 salmon and 12 Salmonidae	-	13 vertebrae	-
Cyprinids: bream, chub, ide and roach	431 skeletal part, of which13 to species and 418 to family Cyprinidae	26 skeletal part	403 skeletal part	2 (urohyale, os pharyngeum)
Total number of bone fragments	2 213	180	1 887	146

Table 3. Identified fish bone fragments from pit 27, comparing the bones remaining on the 4 mm, 2 mm, and 1 mm meshes.

The analysis is from years 2002 and 2004. It includes all identified burned bones found at the site.

A total of 14 678 identified bone fragments.

7.2.1.2 Screening test of Kuopio Nilsiä Lohilahti's pit 27

For this screening test, I asked the Finnish Heritage Agency (former National Board of Antiquities) for the bones of the Kuopio Nilsiä Lohilahti pit number 27 for re-examination. Because only the bones in pit 27 were tested now, the total bone numbers differ from the fragment numbers in the bone analysis presented in the previous chapter, since the results of the previous analysis includes all the bones from the site, including those pike, perch, pikeperch, and cyprinid fragments found in the cultural layers.

At the archaeology laboratory of the University of Helsinki, I screened all of the sandy bones with 4 mm, 2 mm, and 1 mm screens. I screened both identified and unidentified bones. All of the identified fish bones from pit 27 (Nurminen 2004c), as well as the identified bones from the 4 mm, 2 mm, and 1 mm sievings are shown in Table 3. In addition to these bones, a large pile of small fish rib and fin bone fragments (costa, lepidotrichia, pterygiophora) and small fragments of vertebrae not identifiable even to family were found in the denser 1 mm mesh. **The majority of the bones were retained by the 2 mm mesh.**

Results of the Kuopio Nilsiä Lohilahti screening test

The initial assumption was that the 4 mm screen is far too large to recover small fish bones. It seemed self-evident and proved to be correct. Only a fraction of the total number of identified bones remained on the 4 mm screen. **Most of the bones could be retrieved on a 2 mm screen.** In advance, I had thought of the 1 mm screen size as being the absolute best for small bones, but in this experiment the 1 mm mesh left only a very small number of identifiable bones. Most of the bones left on the 1 mm mesh were small fragments of ribs, fin bones, and vertebrae unidentifiable to species or family. A large number of

Fish species/ family	% of identified bones in fine-mesh sieving (total)	% of bones from only the 4 mm mesh
Pike	33 % (without teeth 23 %)	49 %
Pikeperch	0,2 %	0,6 %
Perch and percids	38 %	29 %
Burbot	0,9 %	1,7 %
Whitefish	8,5 %	5,6 %
Salmon and salmonids	0,6 %	0 %
Cyprinids	19 %	14 %

Table 4. Percentage comparison of 4 mm screened and fine-mesh sieved bones from pit 27 at Kuopio Nilsiä Lohilahti.

the pike teeth was also found in the 1 mm mesh. Individual pike have so many teeth that quantifying the teeth relative to the total number of bone fragments inevitably distorts the significance of pike in refuse bone materials by increasing the number of pike bone fragments but not individual pike.

In addition to the bones remaining in the screens, a small number of fragments passed through even the smallest 1 mm screen. These bones included 17 fragments identifiable to species or family. However, this number is so small in percentage terms relative to the rest of the assemblage that it is not relevant to the overall results. Of these identifiable bones, there were 7 fragments of pike (5 teeth and 2 proximal heads of fin bones), 7 fragments of perch (all proximal heads of ribs), and 3 fragments of cyprinids (a proximal head of urohyale and two proximal heads of fin bones). Water sieving is usually considered the best sieving method for the smallest finds, but the absence of these bones would not have been significant in this material. The perch ribs generally pass through smaller holes than the ribs of other fish, as they are narrow and thin at the proximal joint head. The ribs of a small pikeperch can be the same. However, pikeperch has been scarce in Finnish burned bone material and the bones have been mainly from large fish individuals.

It would always be best if all the bone material from the excavation could be recovered to the smallest crumb, because even those fragments passing through the 1 mm sieve can be identified by species. There is always the possibility that this little pile of small fragments can hold the key fragment missing elsewhere in the burned material. Unfortunately, Finnish excavations are most often carried out with external financing, before other land use in the area commences. Time and funding are thus limited, and there are not always the resources to pursue perfection. Therefore, you have to look for compromise, and this screening experiment combines realities with minimal bone loss. **Based on this experiment, I suggest that if a burned fish bone concentration is screened on a 2 mm mesh, the loss may not be very significant.** In this experiment, all the bones found and passed through in the 1 mm mesh were those that were otherwise abundant in the whole material.

If only a 4 millimetre screen had been used

The most common screen size used in archaeological excavations in Finland is 4 mm. Therefore, it is necessary to compare how the use of a 4 mm screen changes the results compared to the use of smaller screen sizes. For this comparison, I used the same bones from the Kuopio Nilsiä Lohilahti pit 27 that I had experimentally retrieved by fine-mesh sieving, as shown in Table 3**.**

Table 4 and Figure 26 show a percentage comparison of the resulting situation if all the fine-mesh sieved bones from the entirety of test pit 27 would have been screened with only a 4 mm mesh, as is sometimes the case in the field. It would have changed the whole distribution of species.

If the bones were sieved on a 4 mm mesh, only 180 fish bones would have been identified

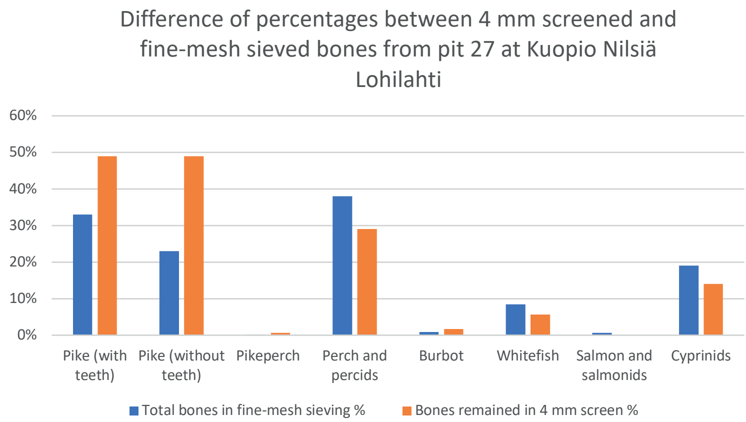


Figure 26. Comparison of find percentages: 4 mm screened and fine-mesh sieved bones from pit 27 at Kuopio Nilsiä Lohilahti.

to species or family. Half of these would have been of pike. The relative proportions of all other species would have changed. However, almost all identified species groups, except for the salmon, were already found on the 4 mm mesh. The use of a denser 2 mm mesh size increased the numbers of perch, salmonids, and cyprinids.

7.2.2 Conclusions and reflection

Water sieving is often considered the best way to recover even the smallest bone fragments. If sieving with water is not possible due to a lack of funding or time, an ordinary punch sieve can also be used. However, this produces some loss in the discovered material, and some species may not be found. If fish bone concentrations are collected with sand to be screened later in the laboratory, any wet sand should be dried first. Wet sand does not pass through a small sieve, but clumps and clogs the entire screen. When screening, it is also necessary to use a respirator, because dry sand will shatter, becoming airborne and causing health problems.

Burned fish bone concentrations should be screened, if water sieving is not possible, using a 2 mm mesh. This increases the number of identified bones as compared to larger mesh sizes, because a large number of bones come from small fish. It gives a more accurate result of the percentage distribution of species, which is relevant to the archaeological interpretation of the site. The use of the finest 1 mm mesh was not relevant to the overall results in this screening test.

The method used to recover burned bones can have a significant effect on the final results. Adding other uncertainties, such as the chance of locating and finding bones in the first place and the problems of taphonomy, it is impossible to appraise the importance of each animal in a human economy on the basis of the number of identifiable bone fragments alone. Each site is unique.

8 Fish bone analyses from Stone Age sites

In this chapter, I present the results of the fish bone analyses made for this study in chronological order, separated into inland and seaside sites. It must be noted that, as explained in chapter *3.1 Formation of land and waters*, many of the Stone Age seaside sites are no longer by the Baltic Sea due to land uplift and shore displacement, and the ancient lakeside sites are mostly nowadays in the middle of the forest, often far from a lakeshore.

Basic research on Stone Age sites in Finland nowadays usually includes radiocarbon dating. Most of the current radiocarbon dating samples are taken from burned bone, but in the 1990s, charcoal was still the most commonly used sample type, as was the case at many of the sites in this study. Burned bone was only recently found to be a more reliable dating material (Lanting et al. 2001).

In previous decades, sites were usually dated based on ceramics and/or shore displacement. This can also be the case in more recent studies when funding is insufficient for radiocarbon dating.

No ceramics have been found in Mesolithic sites. The Finnish Neolithic Age, a time when ceramics were present, but agriculture had yet been adopted (except at the very end of the era), is divided into different periods according to the ceramic groupings, in other words different ceramic styles (see chapter 5 *Archaeological background*).

Shore displacement dating has been a widely spread dating method throughout the archaeological history of Finland and is still used together with radiocarbon dating. The isostatic post-glacial rebound of the underwater land and the position of the shoreline during different eras can be calculated (see chapter 3.1 *Formation of land and waters*), and since the Stone Age dwellings were generally located on a shoreline, the sites can be dated according to the height of the land (Siiriäinen 1974). The site palaeomaps for the times of occupations were made by Perttu Strandman and were estimated on the basis of shore displacement, using the maps of the National Land Survey of Finland.

When the original reference material did not include accurate calibrated radiocarbon dating (CalBCE), as is the case with the older excavations, I calibrated the dating myself using the OxCal 4.3 program. This is mentioned as a reference (OxCal 4.3; Bronk Ramsey 2009) for these dates.

The abbreviations used in this chapter are KM = National Museum (archive) number, MNI = minimum number of individuals and NISP = number of identifiable specimens (fragments). The term “head bones” consists mainly of bones of the viscerocranium and zonoskeleton anterius (see chapter *6.1 Skeleton of a fish*). For the pike, the parietale of the neurocranium is sometimes preserved burned, as well as the frontale of cyprinids, and are included in the term head bones.

Note that bones burned or eroded into shapelessness have not been included in the total numbers found in Finnish bone analyses, as they account for 90-95% of all bone fragments. Also, the results presented in this chapter do not include small pieces of abundant vertebrae, costae, lepidotrichiae or pterygiophorae not identifiable by species or even by family and indicating only that they originated from fish. Instead, all the loose teeth and proximal ends of ribs and fin rays **identifiable** to species or family are included to identify as many bone fragments as possible. This has been the general trend in the identification of burned bones in Finland.

8.1 Inland lakeshore sites

Five of the ten sites were situated inland by the lakeshore during their occupation period (see also Figure 17 in *6.3 Sites with fish bones featured in this study*):

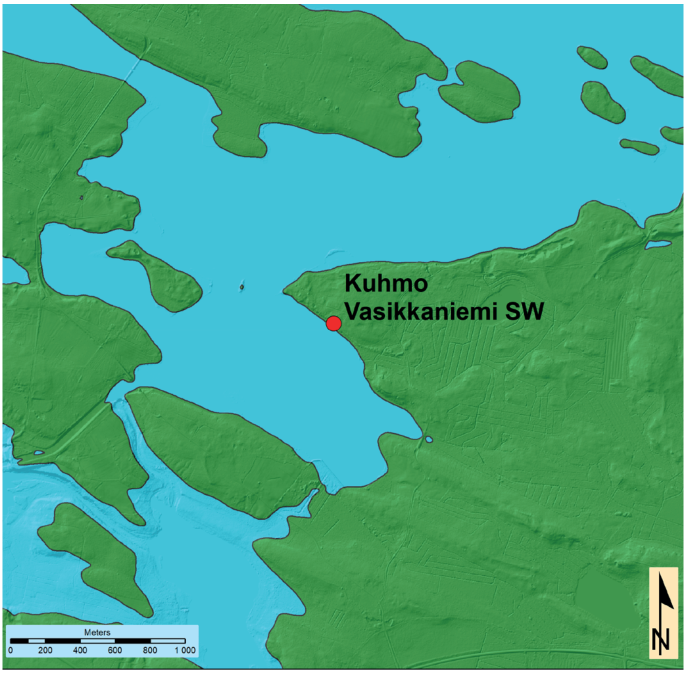


Figure 27. Kuhmo Vasikkaniemi site at the time of Mesolithic occupation (163 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

- Kuhmo Vasikkaniemi SW, Mesolithic
- Taivalkoski Tervaniemi, Mesolithic (/ Early Neolithic)
- Ranua Kultisalmi, Neolithic
- Posio Kuorikkikangas, Late Neolithic
- Puumala Kärmelahti, Late Neolithic

8.1.1 Kuhmo Vasikkaniemi SW

The city of Kuhmo is to be found in the southeast of Kainuu province. The prehistoric site of Vasikkaniemi is located on a cape by Lake Ontojärvi (Figure 27). The site is multi-period, with excavations showing signs of the Mesolithic, Early Metal, Iron and Historical periods. The Mesolithic Age was associated with a stained soil area, an obvious waste pit full of burned fish bones. (Karjalainen 1995; 1996). The bones of this fish deposit were water-screened (Karjalainen 1995). The findings are listed under National Museum inventory number KM 29136.

Charcoal from the discovery contexts of the Mesolithic era was sent for dating (Karjalainen 1995). One sample was taken from a fish bone concentration, but the excavation report does not indicate which of the dated samples it was. The oldest dating was 7380±95 BP (Jungner 1996), corresponding to 6427-6060 calBCE after calibration (OxCal 4.3; Bronk Ramsey 2009), and the two younger 6210±100 BP and 6080±100 BP (Jungner 1996), correspond to 5388-4881 calBCE and 5231-4770 calBCE after calibration (OxCal 4.3; Bronk Ramsey 2009).

Pirkko Ukkonen analysed the mammal and bird bones from the site and a random sample of the tens of thousands of fish bones in the waste pit in 1996. She found bones of terrestrial mammals, such as elk *(Alces alces)*, reindeer *(Rangifer tarandus)*, beaver *(Castor fiber)* and mountain hare *(Lepus timidus)*, and water birds of families Anatidae and Gavia sp. The fish bone sample included 868 fragments of pike (MNI 36), 190 fragments of perch (MNI 29) and 191 fragments of cyprinids (MNI 19). Ukkonen has not identified vertebrae or costae, pterygiophorae, or lepidotrichiae (Ukkonen 1996b).

I re-analysed the fish bones in 2010 in order to try to identify previously unidentified fish species in the data (Nurminen 2010a). I went through all the fish bones and found 1922 more bone fragments that could be identified by species or family. Eleven of these were fragments of cyprinid pharyngeal bones *(ossa pharyngea infe-*

Species/ family	**NISP**	**MNI**	**MNI 1996 + 2010***
Esox lucius (pike)	833	12	41
Perca fluviatilis (perch)	523	21	42
Lota lota (burbot)	4	1	
Coregonus lavaretus (whitefish)	72	3	
Scardinius erythrophthalmus (rudd)	9	7	
cf. *Rutilus rutilus* (possible roach)	3		
R. rutilus/ S. erythrophthalmus (roach/rudd)	2		
cf. Leuciscus cephalus (possible chub)	1		
L. cephalus/ Leuciscus idus (chub/ide)	2		
Cyprinidae (cyprinids)	453	10	18 + rudd 7
Total fish	**1902**		

* The aggregate minimum number of pike, perch and cyprinids of two (1996 and 2010) analyses.
Table 5. Identified fish bones from Kuhmo Vasikkaniemi.

riora) identifiable to species, which Ukkonen had previously identified by family only. Cyprinid pharyngeal bones are suitable for species identification (Lepiksaar 1981, 1983) when the burned fragment is sufficiently large and well preserved. Most of the pharyngeal bones in this assemblage were too fragmented for this purpose.

There were hundreds of small fragments of vertebrae in the random sample fish data Ukkonen had already analysed, most of which were of pike, perch or cyprinids. These species are abundantly represented in the data set, so due to the limited time available I did not count them separately. I only identified the vertebrae of data that Ukkonen had not analysed. Therefore, fish bones from this site cannot be directly used to compare the anatomical distribution of preserved bones, and the total number of bones is not known. Of the other unidentified fish bones in the fish waste pit, I identified all that can be said about the species or family. Table 5 shows the results of my analysis in 2010.

SIZE OF FISH In Vasikkaniemi, the bones of pike, perch, and roach were of all sizes. Some of the bones were of very small fish, “minnows”, some of very large.

In addition to otoliths and scales, which are not preserved in burned bone material, bones can also be used to determine fish age. The most common bones available for this purpose are, e.g., the operculare and cleithrum, are easily removed from the fish. Annual rings can be seen in almost every bone, so other bones can also be used in the absence of the most commonly used bone (Raitaniemi et al. 2000). In burned bone material, the only bones where the annual rings are still visible are the vertebrae. Burned vertebrae can be used to determine the age of the fish, considering the possible destruction of the outer softer layer upon burning (Kari Nyberg, pers. comm.). Therefore, the fish may be older than what the annual rings show.

Counting the annual rings of a vertebra, one of the larger pikes was identified as having been over six years (6+) old. This means that the pike was six years old and the new growing season had already well begun. Based on this, the pike was probably caught in July-August. The outermost growth layer was still clearly visible on this vertebra.

The vertebrae of the burbot and whitefish were estimated to be from fish of about 25-30 centimetres length based on fish with similar size bones in the reference data, and also considering the possible shrinkage of the burned bones.

PIKE The minimum number of pike individuals in both the 1996 and 2010 analyses, calculated both separately as well as combined, was estimated from the front tip of the left dentale. The largest proportion of pike bones was teeth (28%). There were also numerous pieces of the dentale, palatinum, vomer, vertebrae and proximal ends of lepidotrichiae. The large number of pike bones (Figure 28) does not reflect the actual proportion of the species caught, particularly due to the high proportion of teeth and lepidotrichiae, which can number dozens of both in a single pike.

PERCH Most perch bones were vertebrae. The proximal ends of pterygiophorae were also abundant. The minimum number of individuals was calculated from the first cervical vertebra (vertebra I) in my 2010 analysis and the combined minimum number of individuals in the 1996 and 2010 analyses was estimated from the front tip of the left dentale.

BURBOT AND WHITEFISH All bones of burbot and whitefish in the Kuhmo Vasikkaniemi assemblage were vertebrae. I estimated the minimum number of whitefish individuals to be three based on the number of vertebrae, but the real number of original individuals must have been much more; the smaller number seems to be due to preservation problems. The other bones than vertebrae of the whitefish are thin and brittle and rarely survive. The head bones of burbot can also be preserved, but they were not present in this material.

CYPRINIDS Of cyprinids, the only identified species was rudd, with as many as nine pharyngeal bones. Most of the abundant cyprinid pharyngeal bone fragments were either too small themselves or were of individuals that were too small to be identified with certainty. In addition to the rudd, the finds included possible bones of roach, chub and ide. The majority of cyprinid bones were fragments of lower pharyngeal bones and vertebrae. The minimum number of individuals in my 2010 analysis for both the rudd and the family of cyprinids was calculated from the right *(dexter)* pharyngeal bone, and the combined number of individuals in both the 1996 and 2010 analyses of cyprinid fish from the left *(sinister)* articulare.

ON THE SEASONALITY OF THE VASIKKANIEMI SITE The fish material from the Vasikkaniemi site was diverse. The best time for catching fish in coastal waters is during spawning time. Pike, perch, and cyprinids spawn in late spring and early summer, whitefish during the autumn, and burbot in January-February. Pike is an easy catch from the shore all year round, as it prefers to hide in the vegetation of gravelly shores. Perch, roach, and whitefish are also accessible in lakes at other times than spawning, if time when you know the lifestyles of the species.

Figure 28. Burned fish bones (KM 29136:4514), mostly of pike found at Kuhmo Vasikkaniemi. Photo: Markku Haverinen, Finnish Heritage Agency, (https://finna.fi).

Large, spawning-age burbots can only be caught during the spawning season. At other times, they live deep in the water, at the bottom of lakes. According to the fish stocks represented by the bone material, the site was occupied all year round.

8.1.2 Taivalkoski Tervaniemi

Taivalkoski is a municipality of Finland in the north-eastern part of northern Ostrobothnia. Tervaniemi is located on a cape 35 km east of Taivalkoski´s centre, two kilometres southwest of the border of Taivalkoski and Kuusamo municipalities, on the north shore of Lake Ala-Irni. The length of the cape is about 200 m, the width at the

Figure 29. Taivalkoski Tervaniemi site at the time of occupation (240 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Figure 30. Hyomandibulare (left) and palatinum bones of a bream (right). Burned fragments are from the Taivalkoski Tervaniemi site. The reference bones (hyomandibulare to the right, palatina in the top row) are from ca. 2 kg bream.Photo: Tero Nurminen.

base of the cape is about 300 m, and the height is about 150 m. The cape is mostly covered by open bog. The excavation site (Figure 29) is located in a coniferous woodland area, which is clearly higher than the rest of the cape. (Saukkonen 1993).

The excavation yielded a concentration of 8088 burned fish bone fragments in a dark, sooty spot of dirt. The finds are listed under KM 28687. According to the excavation report, the pit was probably not a fireplace, but some kind of small waste pit. The excavation report mentions that the soil was screened but says nothing about mesh size. It also mentions that not all the bones found in the fish pit were recovered (Raike 1994). Pirkko Ukkonen performed the original osteological analyses of the Tervaniemi bones, including elk *(Alces alces)*, reindeer *(Rangifer tarandus)*, bear *(Ursus arctos)* and beaver *(Castor fiber)*, and seven bone fragments of pike (Ukkonen 1994; 1995a). I re-analysed the fish bones in the pit for this study (Nurminen 2010b).

According to the findings, the Tervaniemi site is purely Mesolithic. Radiocarbon dates from the fish bones of the waste pit yielded a date of 6250±100 BP (Raike 1994), corresponding to 4981 calBCE after calibration with a 90.4% probability (OxCal 4.3; Bronk Ramsey 2009), which could also make the site Early Neolithic at the transition point.

The content of the Tervaniemi fish deposit was very interesting. All the bones that were preserved well enough to be identified by species or family originated from cyprinids. They were comprised of 886 bone fragments (11% of all the fish bones in the pit, which is considerable), representing all body parts.

No bones from any other fish family were found. The only species identified with 41 bone fragments was bream. All bones were from approximately the same size fish. The size estimate is about 2-2.5 kilos, so these are larger breams. There were at least 21 breams in the pit (calculated MNI), but most likely more.

No lower pharyngeal bones or fragments of the Weberian apparatus, which are usable in the identification of cyprinid species, were sufficiently well-preserved for this purpose. In my experience, this is usually the case with the pharyngeal bones of bream, which seem to be thinner and more fragile than in most of the other cyprinid fish. I have identified 40 of the bream bones as palatinum bones and one of the hyomandibulare. These bones are not usually used for species identification, but I have noticed over the years

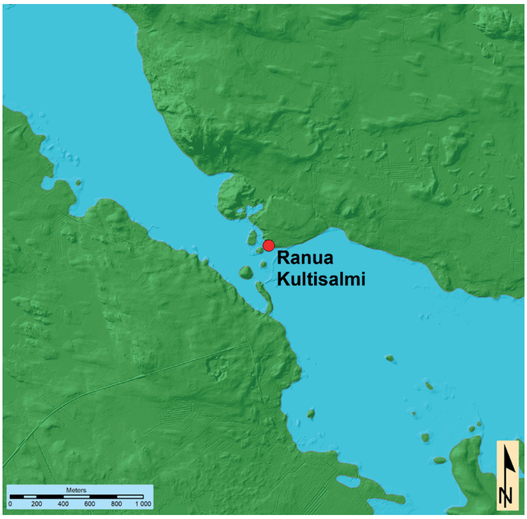


Figure 31. Ranua Kultisalmi site at the time of occupation (177 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

that these two bones of a bream are clearly different from those of the other cyprinid fish (see also Radu 2005). The bream palatinum has a hole in the middle, and the upper part of bream hyomandibulare is higher than that of the other cyprinids (Figure 30).

Cyprinid fish living in shoals spawn along the shores of the coastal waters in the spring. The spawning shoal usually contains only fish of approximately the same size. When not spawning, the shoal could also have been foraging in the coastal waters. As no other species of fish than bream was present, and the individuals were of the same size, it is assumed that these fish represent a single catch of a spawning or eating shoal. Such a shoal is easy to catch, for example, with a seine, which is used to encircle the fish shoal on the shoreline.

8.1.3 Ranua Kultisalmi

Ranua is a municipality in Finland, located in the southern part of the province of Lapland, on the upper and middle reaches of the Simojoki River, south of Rovaniemi. The Stone Age Kultisalmi site (Figure 31) is located in Ranua on the north-eastern shore of Lake Simojärvi (Katiskoski 1990; 1991).

The site of Kultisalmi was excavated over two years, 1990 and 1991. Burned bones were found in both years, especially in refuse pits. The findings are listed under KM 25927 (1990) and KM 26851 (1991). Neither of the excavation reports mentions anything about screening. The dating of this site is unclear, because the radiocarbon analysis results did not fit with the other material discovered (Katiskoski 1991). A total of six carbon samples were sent for radiocarbon dating. The oldest of the samples, 7320±140 BP (corresponds to 6454-5977 calBCE after calibration), dates to the Late Mesolithic, and another sample, 2600±80 BP (923-481 calBCE), to the Early Metal Period. The remaining four samples, 1760±100 BP (52-437 calBCE), 1650±100 (208-601 calBCE), 1570±90 BP (322-650 calBCE), and 1090±110 BP (687-1159 calBCE) point to the Iron Age (Jungner 1992a; 1992b; OxCal 4.3; Bronk Ramsey 2009). Ceramics from the Early Neolithic to the Late Neolithic period were found at the site, but the most abundant are Middle Neolithic ceramics. In any case, the site probably dates back to the Neolithic (Katiskoski 1990; 1991).

The original osteological analyses were made by Pirkko Ukkonen, who found bones of beaver *(Castor fiber)*, elk *(Alces alces)*, reindeer *(Rangifer tarandus)*, whooper swan *(Cygnus cygnus)*, and willow grouse *(Lagopus lagopus)* (Ukkonen 1991a; 1991b). Since Ukkonen did not identify any fish vertebrae, I re-analysed all the fish bones found at the site (Nurminen 2012b; 2012c). The burned bones found at the site of Kultisalmi (Table 6) were much eroded, and only a very small portion could be identified. In such a situation, usually only the hardest bone parts are preserved. Since the 1990 excavation yielded only 24 identifiable fish bones by species or family, and the 1991 excavation no more than 223, I have combined the results.

This result indicates clearly, considering the number of original bones in the fish, how many eroded bones are preserved and what remains of the bones after burning and millennia of erosion (Figures 32, 33 and 34). The hardness of the pike's dentale is particularly evident here, with 51% of all recognizable pike bones being fragments of the dentale. All five whitefish bones were vertebrae. No cyprinids could be identified by species in this material. The anatomical distri-

Species/ family	NISP	MNI
Esox lucius (pike)	182	13
Perca fluviatilis (perch)	37	6
Coregonus lavaretus (whitefish)	5	1
Cyprinidae (cyprinids)	23	2
Total fish	**247**	

Table 6. Identified fish bones from Ranua Kultisalmi.

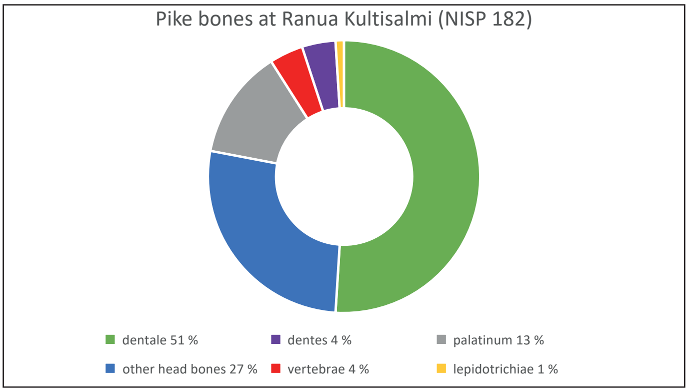


Figure 32. Anatomical distribution of pike bones at Ranua Kultisalmi.

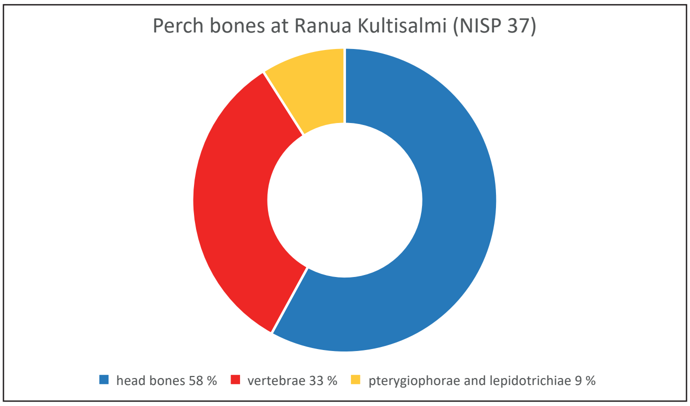


Figure 33. Anatomical distribution of perch bones at Ranua Kultisalmi.

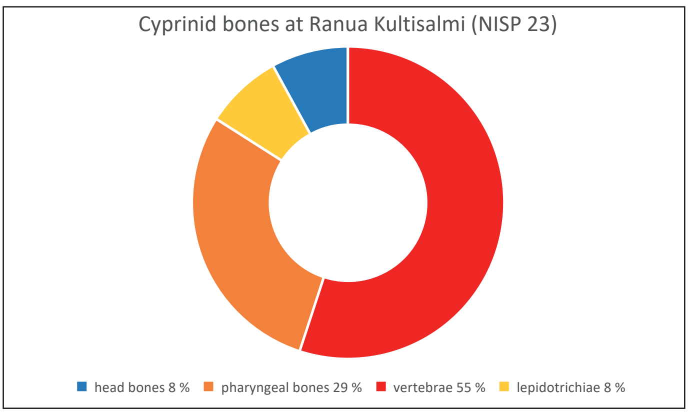


Figure 34. Anatomical distribution of cyprinid bones at Ranua Kultisalmi.

bution of the bones of the identified species are shown in Figures 32, 33 and 34:

8.1.4 Posio Kuorikkikangas

The municipality of Posio is located in southern Lapland. The Kuorikkikangas site (Figure 35) is situated by the Yli-Kitka Kuorikkiselkä lake, on the shores of bays Välilahti and Akanlahti. There was a dwelling in excavation area 1 (Pesonen 1995). The Kuorikkikangas site is dated to the Stone Age and Early Metal Age; the dates derived from charcoal from the dwelling area point to the Late Neolithic, 4140±90 BP and 3940±70 BP (Kankainen 1996), corresponding to 2902-2488 BCE and 2620-2206 BCE after calibration (OxCal 4.3; Bronk Ramsey 2009). The findings are listed under KM 28917. Besides fish, the other animal species found at this site include reindeer *(Rangifer tarandus)*, beaver *(Castor fiber)*, pine marten *(Martes martes)*, mountain hare *(Lepus timidus,)* and willow grouse *(Lagopus lagopus)* (Ukkonen 1996c).

Figure 35. Posio Kuorikkikangas site at the time of occupation (245 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Burned fish bones were found in excavation areas 1, 2 and 3. The screen size used in the excavation was 5 mm (Pesonen 1995). Some of the bones from area 1 were analysed by Pirkko Ukkonen in 1996. For this study, I re-analysed all the fish bones found in the three excavation areas, including both the previously analysed and unanalysed bones (Nurminen 2011).

The total amount of fish bones was 3449, of which 1982 fragments were identifiable to family or species. The high percentage of identifiable bones is probably due to the large 5 mm sieve size used in the excavation, which is why the more often unidentifiable smaller burned fish bones were apparently not recovered. I have compiled (Table 7) a summary of the identified fish bones found at the Kuorikkikangas site. Below this, I present detailed results for excavation areas 1, 2 and 3.

AREA 1, THE DWELLING AREA Two hearth bottoms with burned bones were found, one at each end of the dwelling (Pesonen 1995). These

Species/ family	NISP	MNI
Esox lucius (pike)	893	44
Perca fluviatilis (perch)	485	24
Lota lota (burbot)	5	1
Coregonus lavaretus (whitefish)	75	3
Rutilus rutilus/ (Leuciscus idus) [roach/(ide)]	1	
R. rutilus/ L. idus (roach/ide)	2	
cf. L. idus (possible ide)	3	
Cyprinidae (cyprinids)	518	13
Total fish	**1982**	

Table 7. Identified fish bones from Posio Kuorikkikangas (total result of all three excavation areas).

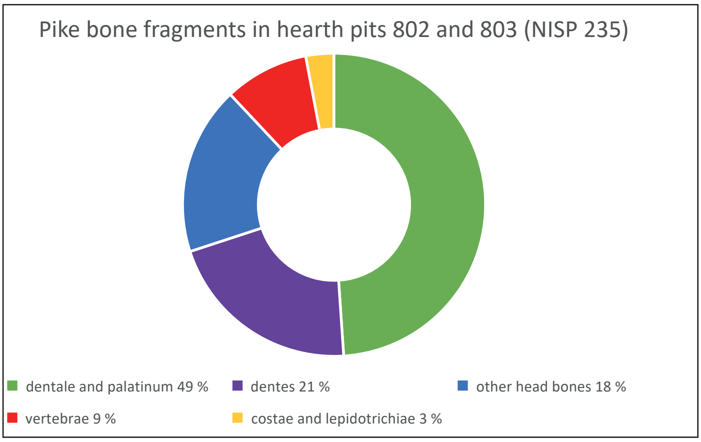


Figure 36. Anatomical distribution of pike bones in hearth pits :802 and :803 in Area 1 at Posio Kuorikkikangas.

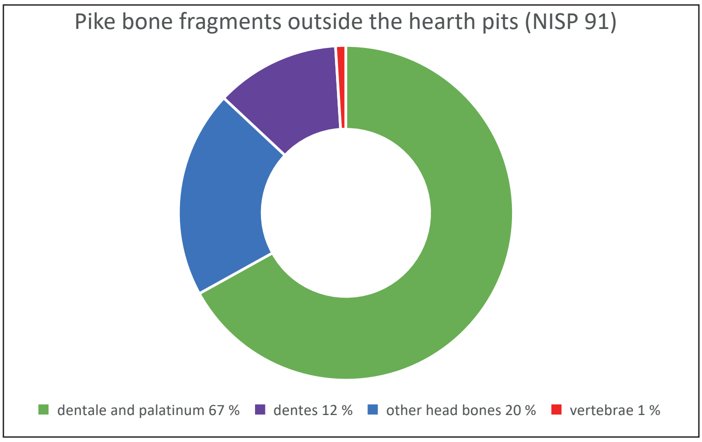


Figure 37. Anatomical distribution of pike bones outside the hearth pits in Area 1 at Posio Kuorikkikangas.

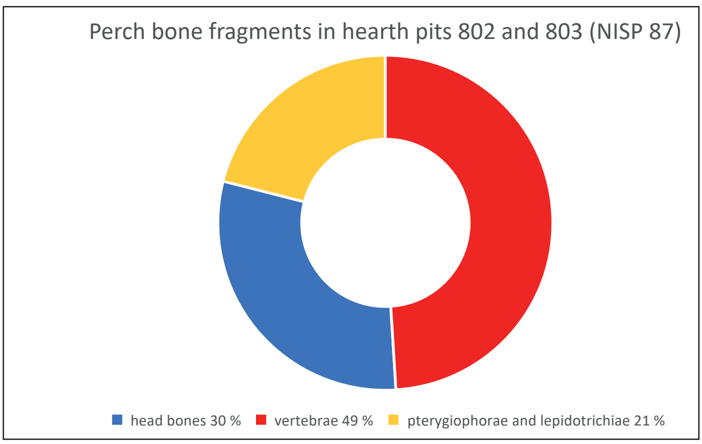


Figure 38. Anatomical distribution of perch bones in hearth pits :802 and :803 in Area 1 at Posio Kuorikkikangas.

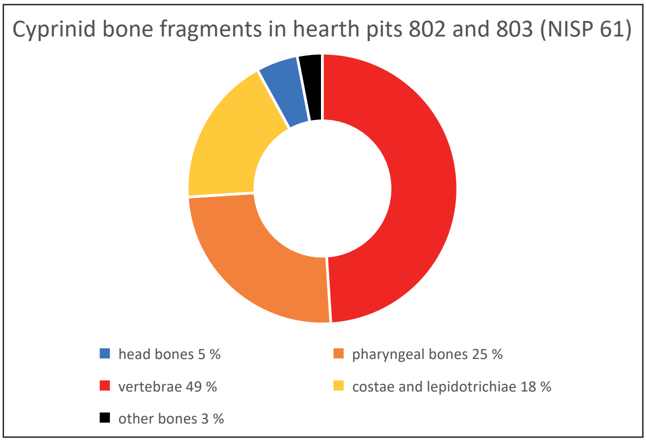


Figure 39. Anatomical distribution of cyprinid bones in hearth pits :802 and :803 in Area 1 at Posio Kuorikkikangas.

bone concentrations are listed under KM 28917:802 and KM 28917:803. The fish distribution for Area 1 (total, including both of the hearth bottoms and the cultural layers) is shown in Table 8.

All species of fish identified in Area 1 were found in both hearth concentrations. The bones were dark grey, dirty and brittle, as is usually the case with burned bones found in hearth bottoms.

No cyprinids were identifiable by species. There was one larger piece of a lower jaw (dentale) in the hearth pit: 802, which due to its size may belong to a bream or an ide. Chub and asp are in principle also potential species, but due to the northern location of the site I do not consider them probable.

The anatomical distributions by species of the identified fish bones from Area 1 is shown in Figures 36, 37, 38, and 39. The pike bones found in the hearths have separate diagrams (Figure 36), as do the bones found outside the hearths (Figure 37). All the whitefish bones were vertebrae, of which 53 out of 54 were found in the hearths.

All the perch (Figure 38) and cyprinid (Figure 39) bones shown in these diagrams were found in the two hearths. In addition to these, only 11 bone fragments that were not pike were identified outside the hearths: two perch head bones, one whitefish vertebra and eight bone fragments of cyprinids, three head bones, four vertebrae and a fragment of basipterygium.

AREA 2 A little to the north of the dwelling in Area 1, excavation Area 2 yielded numerous burned fish bones (Table 9) from the stained soil among the burned stones. The fish bones in Area 2 were partly white and partly dark grey. The preservation of the bones ranged from poor to fine. The bones were mostly quite small fragments.

The taxonomic composition of the fish bone assemblage was more diverse than in Area 1. Pike, perch, and cyprinid bones originated generally from individuals of variable sizes, including very large and very small fish.

All eight burbot bones, including seven vertebra fragments, were found in Area 2. The fragment of a burbot maxillare (KM 28917:1958) was very well preserved (Figure 40). Its size roughly corresponded to that of my 1.5 kg refer-

Species/ family	NISP	MNI
Esox lucius (pike)	326	11
Perca fluviatilis (perch)	89	10
Coregonus lavaretus (whitefish)	54	2
Cyprinidae (cyprinids)	69	2
Total fish	538	

Table 8. Identified fish bones recovered from Area 1 at Posio Kuorikkikangas.

Species/ family	NISP	MNI
Esox lucius (pike)	394	19
Perca fluviatilis (perch)	367	11
Lota lota (burbot)	8	1
Coregonus lavaretus (whitefish)	22	1
Rutilus rutilus/ (Leuciscus idus) [roach/(ide)]	1	
R. rutilus/ L. idus (roach/ide)	1	
Cyprinidae (cyprinids)	398	9
Total fish	**1191**	

Table 9. Identified fish bones recovered from Area 2 at Posio Kuorikkikangas.

Figure 40. Burbot maxillare (KM 28917:1958) and three vertebrae from Area 2. The complete maxilla of a reference specimen is shown to the right. Photo: Tero Nurminen

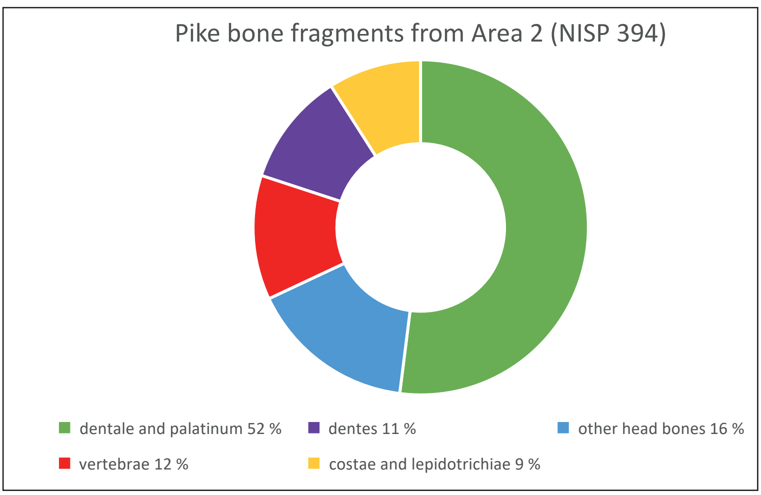


Figure 41. Identified pike bones from Area 2 at Posio Kuorikkikangas.

Figure 42. Identified perch bones from Area 2 at Posio Kuorikkikangas.

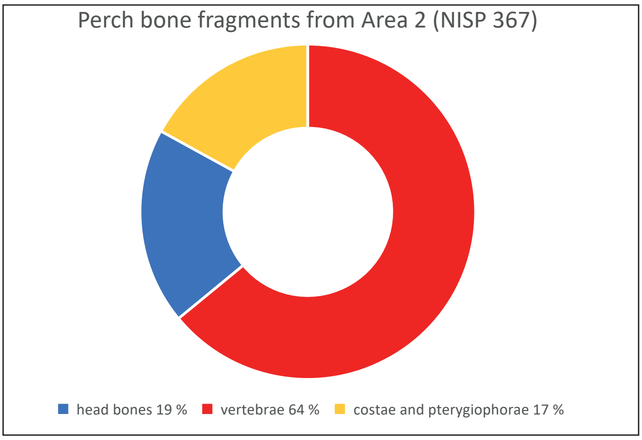
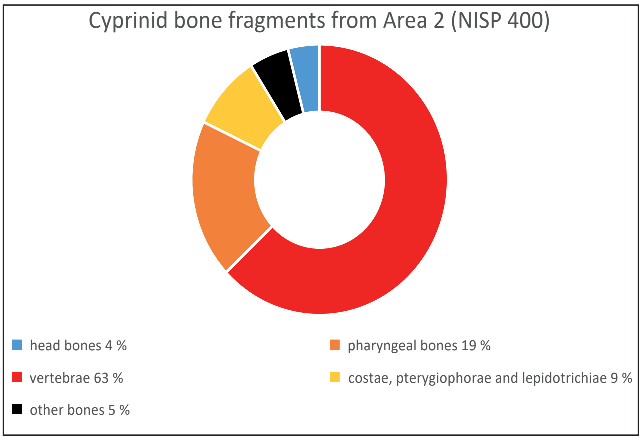


Figure 43. Identified cyprinid bones from Area 2 at Posio Kuorikkikangas.



ence burbot. Because bones tend to shrink slightly when they burn, this bone may derive from a slightly larger fish. Three burbot vertebrae (KM 28917:1565, 28917:1722 and 28917:1874) also originated from large individuals. Even when burned, they were larger than the vertebrae of my reference fish.

Of the cyprinid family, there was a whole palatinum bone (KM 28917:2045). During fish bone analyses over the years I have noticed that the palatinum bones of cyprinids seem to be species-specific (more about this in chapter 9.2 *Case study 2: Cyprinids in the Stone Age*, see also Radu 2005). This bone was entirely reminiscent of the roach's palatinum, but was much larger in size than the largest roach in my reference collection, the Finnish size-record roach (1,192 grams), which was caught in Posio (NB in the same municipality!) in 2007. A reference palatinum from a large ide was a good fit in terms of size, but the shape did not quite match. I only have one reference skeleton of a large ide. The reference collection should be larger to be able to exclude ide for sure, since these bones have not been studied in general, and therefore there is always the possibility that there may be individual differences in the bones as well as differences between genera. If this bone is really the palatinum of a roach, which I strongly believe, roaches have grown significantly larger during the Stone Age than today. This may be because they were then under less fishing pressure by the smaller human population than is currently the case when "junk" fish are regularly removed from lakes to prevent excessive eutrophication. I have marked this identification in the list of bones as roach/(ide).

Species/ family	NISP	MNI
Esox lucius (pike)	182	14
Perca fluviatilis (perch)	31	3
Salmonidae (salmonids, including whitefish)	1	1
cf. *Leuciscus idus* (possible ide)	3	1
Rutilus rutilus/ L. idus (roach/ide)	1	
Cyprinidae (cyprinids)	47	2
Total fish	**265**	

Table 10. Identified fish bones recovered from Area 3 at Posio Kuorikkikangas.

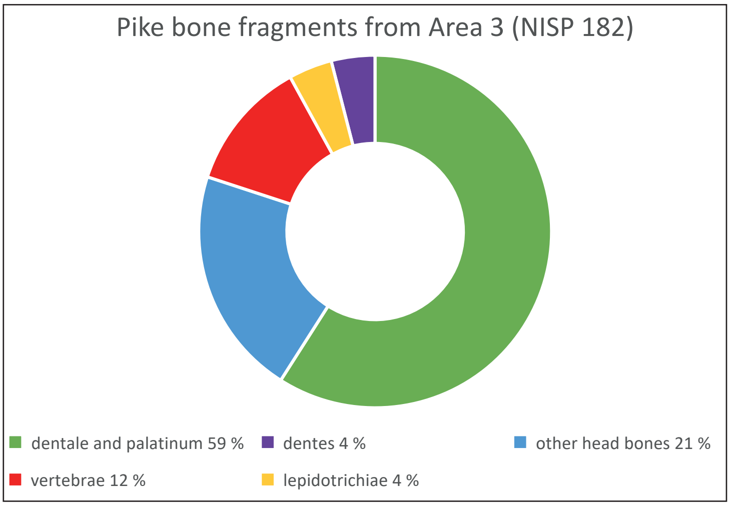


Figure 44. Identified pike bones from Area 3 at Posio Kuorikkikangas.

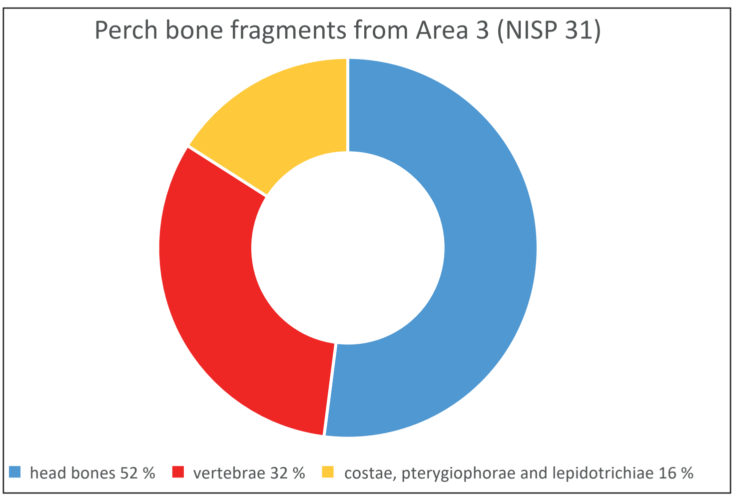
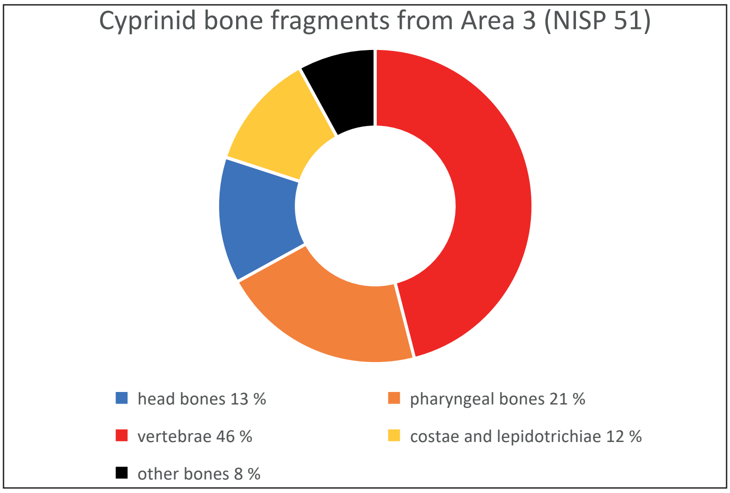


Figure 45. Identified perch bones from Area 3 at Posio Kuorikkikangas.

Figure 46. Identified cyprinid bones from Area 3 at Posio Kuorikkikangas.



The other cyprinid bone identified as roach/ide is a fragment of the pharyngeal bone. There were as many as 73 fragments of cyprinid pharyngeal bones in Area 2, and only this one fragment was somewhat identifiable to species. This gives a good idea of how badly fragmented burned fish bones usually are.

All the whitefish bones were vertebrae. Figures 41, 42 and 43 show the anatomical distributions of the identified pike, perch, and cyprinid bones from Area 2. The importance of identifying vertebrae, costae, pterygiophorae. and lepidotrichiae is well illustrated by the bones in this area.

AREA 3 Excavation Area 3 was adjacent to Area 2. Burned bones were found in stained soil among burned stones; most obviously the feature was a hearth pit. The bones in Area 3 were almost white and chalky, poorly preserved and eroded. Their distribution by fish taxa is shown in Table 10 and the anatomical distributions of identified pike, perch, and cyprinid bones in Figures 44, 45, and 46.

A large part of the fish bones in this area were pike remains. They were mainly hard, well-preserved fragments of the jaws. Because the bone material was heavily burned, it is likely that the more fragile bones have disappeared over time. One specimen (KM 28917:2405) was a piece of a huge pike palatinum, originating from a pike weighing at least 7-8 kg. Other large pike bones were also found. In addition to these, the fish bone material contained bones of many sizes of fish, including tiny ones. In KM 28917:2810 there were two very small vertebrae of perch or cyprinid. These two groups of fish cannot be distinguished beyond a doubt from such small vertebrae using the microscope I have available in the Finnish Museum of Natural History LUOMUS.

A cyprinid vertebra fragment of the Weberian apparatus II (KM 28917:2512) came from a fish of larger size than bream. The most likely alternative, given the northern location of the site, is ide. In addition, large dentale and basipterygium fragments (KM 28917:2848) are most probably those of ide. They are perfectly suited to the shape of ide bones, but not to any other large-growing cyprinid. However, these bones are usually not used in species identifications and would thus require a larger reference collection in order to make a reliable assessment of species.

8.1.5 Puumala Kärmelahti

The municipality of Puumala is located in the Lake Saimaa region of southern Savonia. The Kärmelahti site (Figure 47) is on the western shore of Lehmäinselkä, northeast of the strait between Kärmelahti and the small clear-water pond Kärmelampi. The Stone Age site is on the highest, almost flat terrace of Ancient Lake

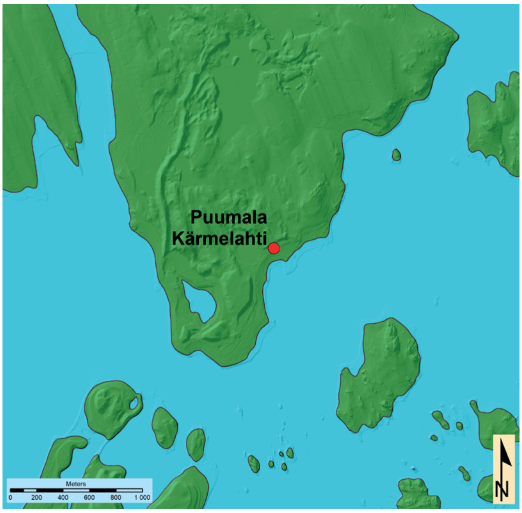


Figure 47. Puumala Kärmelahti site at the time of occupation (81-84 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Saimaa (Katiskoski 1998; 2002).

Three dwelling pits were found in the Kärmelahti site, and the largest of them was excavated for two consecutive summers in 1998 and 1999. The findings are listed under KM 31376 (1998) and KM 31879 (1999). According to the wall remains found, there was a house (Katiskoski 1998; 1999; 2002) dated to the Late Neolithic, between 4615 – 4465 BP (Jungner 1999; Kankainen 2000), corresponding to 3532 – 3009 calBCE after calibration (OxCal 4.3; Bronk Ramsey 2009). The dwelling had two concentrations of stained soil inside, probable from hearths or cooking pits, which were rich in small burned bones, and a minor burned bone concentration with red coloured dirt. The soil was screened with different size screens, ranging from 4 to 8 mm, but the excavation report does not indicate how the bone deposits, or the bones overall, were screened. (Katiskoski 1998; 1999).

Kristiina Mannermaa has analysed the burned mammal and bird remains, and some of the fish bones, found in the Kärmelahti site. The identified mammals are elk *(Alces alces)*, beaver *(Castor fiber)*, dog *(Canis familiaris)*, fox *(Vulpes vulpes*), pine marten *(Martes martes)*, mountain hare *(Lepus timidus)*, and the family of seals (Phocidae), along with the bird bones of diver (loon) *(Gavia arctica)* and red-throated diver *(Gavia stellata)* (Katiskoski 2002; Mannermaa 1999a; 1999b). I have re-analysed all the fish bones, both previously identified and not previously analysed, for this study (Nurminen 2010c; 2010d). The bone material was heavily fragmented, and only a small part of the bones could be identified to species or family. There were no differences between the 1998 and 1999 fish bone finds, nor between the studied areas and bone concentrations. The results (Table 11) can thus be combined as one.

According to excavation reports, the total number of burned bones recovered was closer to 13 000 fragments, most of which were fish bones (Katiskoski 1998; 1999). As only 418 fragments of identified fish bones were obtained, this shows how eroded and poorly preserved the bones are at this site. With such poor bone preservation, only the hardest bone fragments are left in an identifiable condition, which increases the number of pike bones relative to other species. Another reason for these quantitative differences between species is probably the use of a large

Species/ family	**NISP**	**MNI**
Esox lucius (pike)	256	23
Perca fluviatilis (perch)	93	8
Coregonus lavaretus (whitefish)	13	1
Leuciscus idus (ide)	1	1
Cyprinidae (cyprinids)	55	4
Total fish	**418**	

Table 11. Identified fish bones recovered from Puumala Kärmelahti

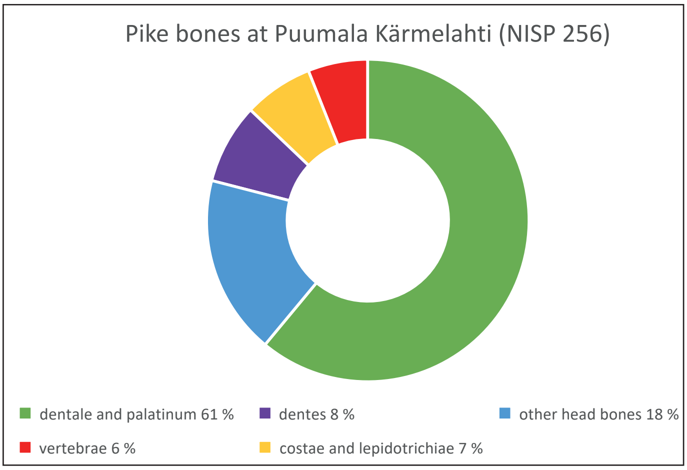


Figure 48. Anatomical distribution of pike bones at Puumala Kärmelahti.

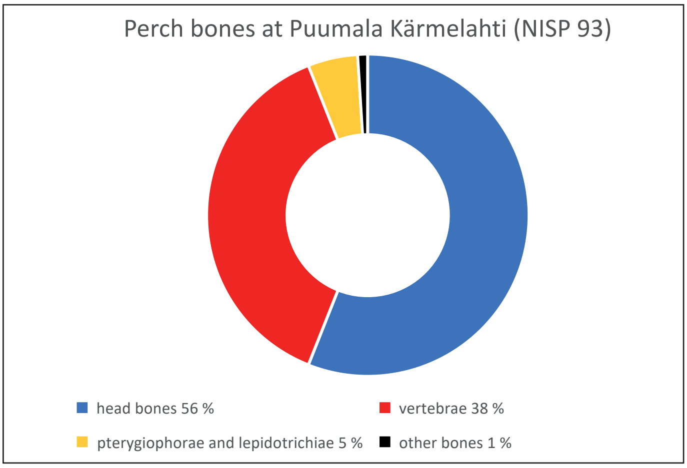


Figure 49. Anatomical distribution of perch bones at Puumala Kärmelahti.

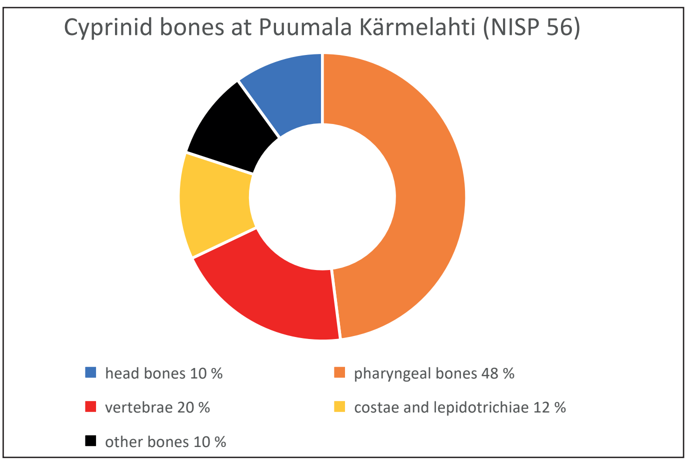


Figure 50. Anatomical distribution of cyprinid bones at Puumala Kärmelahti.

mesh size (4-8 mm) in Kärmelahti, which has apparently left the smallest bones unrecovered, and which may explain, for example, the lack of hard and generally well-preserved vertebrae of often smaller-size cyprinids.

The anatomical distributions of identified pike, perch and cyprinid bones by species in Puumala Kärmelahti site are shown in Figures 48, 49, and 50. All the whitefish bones were vertebrae.

8.2 Baltic (Littorina Sea) coastal sites

Five of the ten sites were situated by the Littorina Sea coast during their occupation periods (see also Figure 17 in *6.3 Sites with fish bones featured in this study*):

- Askola Siltapellonhaka, Middle Mesolithic
- Ii Kuivaniemi Veskankangas, Late Mesolithic
- Oulu Ylikiiminki Latokangas, Early Neolithic
- Simo Tainiaro, Early Neolithic
- Virolahti Meskäärtty, Late Middle and Early Late Neolithic

8.2.1 Askola Siltapellonhaka

Askola is a municipality in southern Finland in the province of Uusimaa. The Siltapellonhaka site (Figure 51), currently located on the south-eastern bank of the Porvoonjoki River, was an archipelago of the Littorina Sea during the Mesolithic Stone Age. The site was excavated in 2012 and is dated to the Middle Mesolithic based on shore displacement. (Pesonen 2012). Radiocarbon analyses of burned elk and seal bones found during excavation date the site to the same era, between 7738±47 and 7492±44 BP (Possnert 2012), corresponding to 6646-6251 calBCE after calibration (OxCal 4.3; Bronk Ramsey 2009).

Finds (KM 39157) from the Siltapellonhaka site were screened with a 4 mm mesh, and a large amount of burned bone was found during the excavation (Pesonen 2012). There is no clear hearth bottom or waste pit associated with the abundant fish bone assemblage recovered from this site. I

Figure 51. Askola Siltapellonhaka site at the time of occupation (30-45 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Species/ family	NISP	MNI
Esox lucius (pike)	21	2
cf. *Esox lucius* (possible pike)	1	
Sander lucioperca (pikeperch)	21	5
cf. *Sander lucioperca* (possible pikeperch)	4	
Perca fluviatilis (perch)	4	2
Percidae (percids: pikeperch or perch)	18	
Sander lucioperca/ Salmo sp. (pikeperch/salmon or trout)	1	
cf. *Sander lucioperca*/ Salmo sp. (possible pikeperch/salmon/trout)	1	
Salmonidae (salmonids)	1	1
Abramis brama (bream)	1	1
cf. Aspius aspius (possible asp)	3	
Cyprinidae (cyprinids)	112	13
Total fish	**188**	

Table 12. Identified fish bones from Askola Siltapellonhaka.

carried out an osteological analysis of the material for the Finnish Heritage Agency (Nurminen 2012d), and after reviewing the results I also found the data to be suitable for reflection on fishing in the Finnish Stone Age. Although there is no typical fish bone concentration in a hearth bottom or waste pit, the fish bones were still notably concentrated within a few square meters in the excavation area and are predominantly in a different location from the mammalian bones found at the occupation site (Pesonen 2012).

The burned bones found at the Askola Siltapellonhaka site were abundant but largely poorly preserved. They were eroded and in the form of very small fragments, mostly light brown in colour, with some light grey specimens among them. Most of the mammalian bones were small, shapeless fragments. The material contained some fish and a few bird bones as well. These latter fragments, however, were better preserved than those of the mammals. Some were corroded, probably due to the low degree of burning and the resulting susceptibility to erosion. In addition to fish, I identified the remains

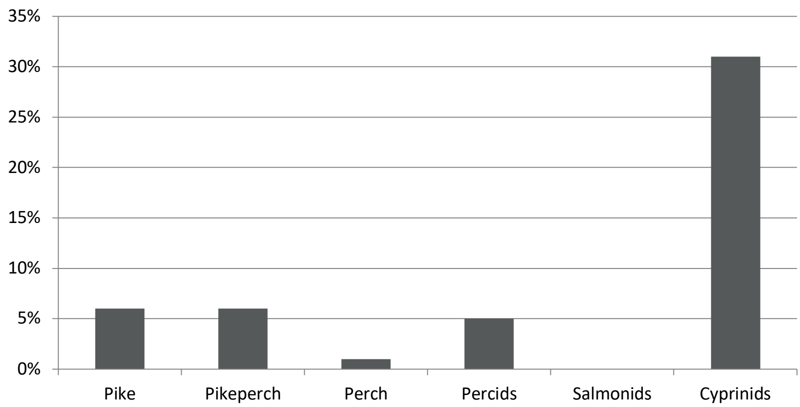


Figure 52. The percentages of identified fish from Askola Siltapellonhaka.

of elk *(Alces alces)*, seal (Phocidae), and diver *(Gavia arctica)* bones (Nurminen 2012d).

The total amount of fish bones was 379, of which 188 fragments were identifiable to family or species (Table 12).

Bone abrasion and poor preservation have caused many uncertain identifications in this material. Therefore, nothing can be said about the significance of any species at the site. In any case, the fish refuse material from the Siltapellonhaka site was different from the typical Stone Age fish assemblage (Figure 52). Fish refuse bone samples are usually dominated by pike or perch. This material contained at least 21 bones of much rarer pikeperch. However, most of the identified remains originated from cyprinids.

PIKE There were surprisingly few pike remains in the Askola material. The pike bones were mainly jaw fragments and some articular surfaces of the other head bones. The minimum number of individuals is only two; one from a small fish and the other from a very large one.

PIKEPERCH Pikeperch is rarely found in Stone Age food refuse and is usually represented by a single fragment of the front lower jawbone (dentale). The Askola material contained more pikeperch bones, including also bones other than jaws, such as the articulare, praemaxillare, maxillare, palatinum, basioccipitale, and vertebrae. All the bones were from large individuals, as is typical of pikeperch bone finds. The minimum number of individuals of pikeperch is five.

PERCH Perch is usually abundant in the Stone Age material but only four fragments were found in Askola. Some of the bones, mostly vertebrae, that were identified as percids may belong to perch, and some to pikeperch. This must be related to the poor preservation of bones in general at this site. The larger 4 mm screen size is probably also significant for the likely loss of the usually smaller perch bone fragments.

SALMONIDS Only small traces of salmonid fish - whitefish, salmon, or trout - were found in the Siltapellonhaka material. One bone, an articular joint of a quadratum, was clearly that of a salmonid but could not be identified by species. There was none of the usually common whitefish in Askola. Two eroded dentale fragments may have belonged to either pikeperch or salmon or trout.

CYPRINIDS Only one definite species of cyprinids, bream, and possibly asp, were identifiable in the Askola Siltapellonhaka bone material. The identified bream bone is the upper part of a hyomandibulare, and the three possible asp bones are fragments of an articulare, pharyngeal bone, and scapula respectively. The potential asp was very large, weighing more than the 4.8 kg reference specimen I have. In addition, one fragment of a pharyngeal bone belonged to some other species of cyprinids, most probably roach, rudd, ide, or chub.

DISCUSSION

The larger relative amount of pikeperch makes the Siltapellonhaka bone material interesting. In general, the bones of the fish were from large individuals. The material contained several small outer edge fragments of very large fish vertebrae. The diameter of these vertebrae must have been closer to 3 cm. Such a fish would have been a real giant; it may have weighed at least twenty kilos if not much more. In principle, a pike, pikeperch or salmon can grow very large, and then there is the potentially huge wels, which is now extinct in Finland, but whose bones have been found in Stone Age contexts.

The distribution of the fish in a site may be due to either natural conditions or pure coincidence. The species distributions of fish identified at inland Stone Age sites can generally be easily explained by the eutrophics of the lake or the proximity to flowing water, assuming that fishing has taken place from the shoreline. Askola was located in the marine archipelago of the Gulf of Finland during the Stone Age, and conditions at sea were different from those in ordinary inland habitats. For example, there may be great differences in the depth of the shoreline and the sea is of course often deeper than lakes.

The presence of large pikeperch bones may suggest the use of large-meshed fishing nets in deeper waters. On the other hand, pikeperch fishing may have been concentrated on the early summer spawning time. A prerequisite for the occurrence of pikeperch in Finnish coastal waters is sheltered inland bays where the water is warm enough to spawn. After spawning, the pikeperch stays in the bay to eat, but will disappear into the deep waters as the water cools in late summer (Yrjölä et. al 2015). In coastal waters, June and July are the season for catching pikeperch. These summer months, together with springtime, are also lucrative along the coast for fishing for cyprinids, while pike and perch can be more easily caught year-round. Based on the bones, the Askola Siltapellonhaka site may be a seasonal spring-summer camp.

When making these conclusions, we must remember that the 4 mm mesh size used during the excavation is rather large for the recovery of burned fish bones, which is reflected in the large size of the identified fish individuals. Smaller bones may not have been recovered, which would directly affect the species distribution.

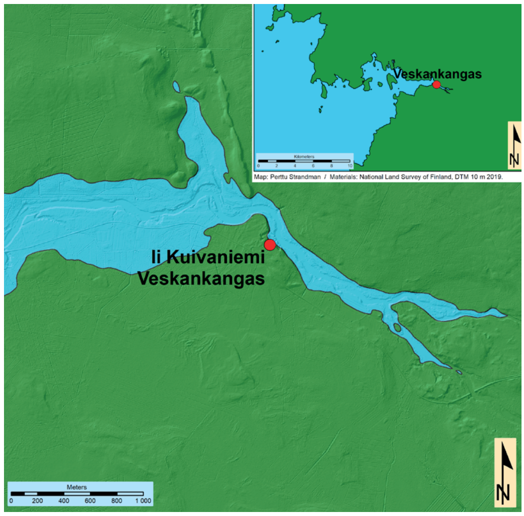


Figure 53. Ii Kuivaniemi Veskankangas site at the time of occupation (85-90 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

8.2.2 Ii Kuivaniemi Veskankangas

The former municipality of Kuivaniemi, now part of the Ii municipality, is located on the north-eastern shore of the Gulf of Bothnia between the cities of Oulu and Kemi. Veskankangas is a wide Stone Age site (Figure 53), dated to the Late Mesolithic based on shore displacement, located on the southwestern bank of the Kuivajoki River, on the former shores of the Littorina Sea. Excavations were carried out for several years, in 1958 by Ville Luho and then from 1988-1992 (Wallenius 1988; 1989a; 1989b; 1990a; 1991a; Wallenius & Lauren 1992). The findings are listed under KM 14535 (1958), KM 24423 (1988), KM 24928 (KM 1989), KM 25800 (1990), KM 26699 (1991) and KM 27365 (1992). Carbon samples from the hearths of the 1989 and 1990 excavations were sent for dating, with results ranging from 6290±120 to 5990±110 BP (Wallenius 1990a), corresponding to 5471-4654 calBCE after calibration (OxCal 4.3; Bronk Ramsey 2009). There is no original report for these radiocarbon dates attached to the excavation report.

The excavation reports mention neither sieving, nor the contexts in which the burned bones have been found. There are dozens of fireplaces and stained garbage disposal soil areas in the site. The only mention of fish finds is in the 1990 excavation report, which states that cyprinid bones came from the bottom of the dwelling (Wallenius 1990a). When I analysed these bones, I noticed that they were grey and sooty, and thus most obviously from the bottom of a hearth (Nurminen 2012h). These excavations have been made at the turn of the 1980s and the 1990s, when actual osteological analyses of the Stone Age animal refuse fauna were just beginning in Finland. Therefore, it can be assumed that the burned bones may not have been recovered as accurately as would be commonly done today. Most probably the smallest fish bones have not been recovered.

Osteological analyses done in the early 1990s mention an abundance of mammal species and several birds. Most of the mammal bones are of seals (Phocidae). Other mammalian species include elk *(Alces alces)*, beaver *(Castor fiber)*, otter *(Lutra lutra)*, fox *(Vulpes vulpes)*,

Species/ family	NISP	MNI
Esox lucius (pike)	746	61
Sander lucioperca (pikeperch)	19	3
cf. Sander lucioperca (possible pikeperch)	4	
Perca fluviatilis (perch)	101	7
Percidae (percids: pikeperch or perch)	19	
cf. Percidae (possible percids)	1	
Lota lota (burbot)	1	1
cf. Lota lota (possible burbot)	1	
Myoxocephalus quadricornis (four-horned sculpin)	1	1
Coregonus lavaretus (whitefish)	48	2
cf. Salmo salar (possible salmon)	4	
cf. Salmo trutta (possible trout)	1	
Salmonidae (salmonids, including whitefish)	97	
Abramis brama (bream)	15	6
cf. Abramis brama (possible bream)	2	
Rutilus rutilus/ Leuciscus cephalus (roach/ chub)	1	
cf. Carassius carassius (possible crucian carp)	1	
cf. Leuciscus idus (possible ide)	1	
cf. Rutilus rutilus (possible roach)	2	
Cyprinidae (cyprinids)	494	29
Total fish	**1559**	

Table 13. Combined results of all identified fish bones from Ii Kuivaniemi Veskankangas.

pine marten *(Martes martes,)* and mountain hare *(Lepus timidus)*. Birds have been identified as whooper swan *(Cygnus cygnus)*, long-tailed duck *(Clangula hyemalis)*, capercaillie *(Tetrao urogallus,)* and willow grouse *(Lagopus lagopus)* (Ukkonen 1990a; 1990b; 1991c; 1992; Nummela 1992). This indicates that a very diverse range of species of both forest and coastal fauna were exploited at the site.

Since fish vertebrae were not identified at the time, and the fish bone reference collection was very limited in the 1990s, I have re-analysed all the burned fish bones for all of the excavation years for this study (Nurminen 2012e; 2012f; 2012g; 2012h; 2012i; 2012j; 2012k). The bones from the 1958 excavation had not been analysed before at all, but there were only 11 identifiable fish bones in the assemblage: seven of pike, one of perch, and three of cyprinids (Nurminen 2012e). In the absence of more detailed information on the position of the fish bones in hearths or waste pits, with the exception of the cyprinid bone concentration at the bottom of a hearth (which does not include all the cyprinid bones found in this site), I have combined all of the material, totalling with 1559 identified fish bones (Table 13, Nurminen 2012k).

The range of preservation of the fish bones from Veskankangas was very broad. Some were well preserved and had clearly preserved shapes, while others were much eroded. Because many of the bones were much eroded, there are many uncertain identifications in the results, which are labelled as “possible” or just by family. However, this does not really matter when looking at the results, since the same species have already been identified in this material, except for cyprinids, whose pharyn-

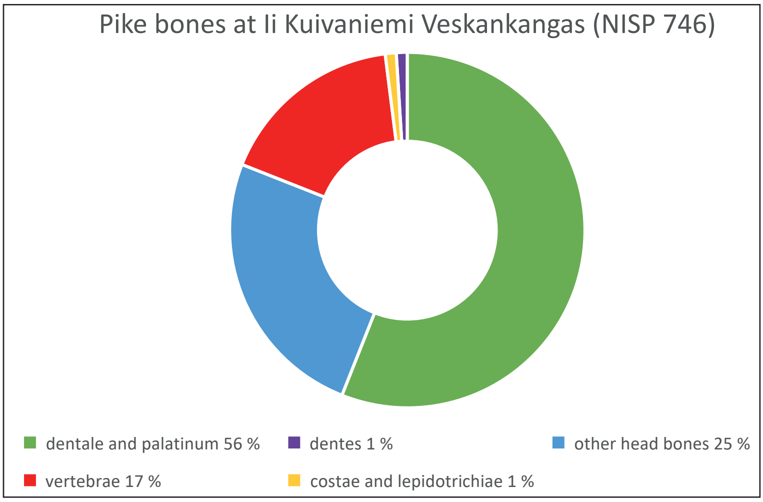


Figure 54. Anatomical distribution of pike bones at Ii Kuivaniemi Veskankangas.

geal bones were largely too fragmented for species identification. Bones of pike, perch, and cyprinids were preserved from all parts of their skeletons. Some of the pike bones were from very large individuals, almost like "giant pikes". The anatomical distribution of pike bones is shown in Figure 54.

The 97 bone fragments identified as salmonids were very small vertebra fragments, most of which most likely originate from whitefish, but other salmonids may also have been present. As an exception compared to other assemblages, this bone material also contained two whitefish bones other than vertebrae: the articular surfaces of an articulare and a quadratum.

There were two bones of burbot in this material, a vertebra and maxillare. The latter was so eroded that I have left the species determination uncertain. The age of the burbot whose vertebra was found was 5+, based on the vertebral annuli. This individual was probably caught during the winter, as the new annulus had already begun to grow. Burbot grows well during the winter spawning time, while in other fish growth stops in the winter and does not start until spring

Figure 55. Pikeperch bones, KM 24928:916 with modern comparative bones. Top centre: vertebra. Middle row left: palatinum, right: praemaxillare. Bottom row: dentalia. In the middle and bottom rows, modern reference specimens are shown below the archaeological fragments. Photo: Tero Nurminen

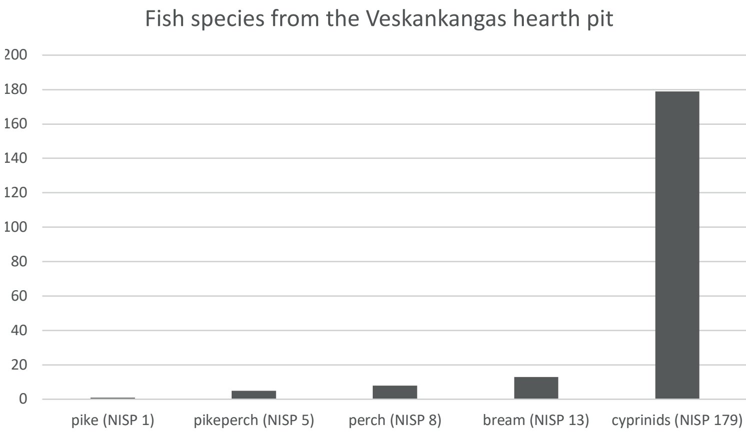


Figure 56. Identified fish bones (NISP) from the hearth pit at Ii Kuivaniemi Veskankangas.

(Raitaniemi et al. 2000).

A special find in this material was the first cervical vertebra of a fourhorned sculpin. Fourhorned sculpin has not previously been found at Stone Age sites in the area of present-day Finland, although it is thought to have been common in Finland already during the Mesolithic (Yrjölä et al. 2015).

Pikeperch is relatively rare in Finnish Stone Age refuse materials, but the Veskankangas material contained several large and magnificent fragments of pikeperch bone, some of which are shown in Figure 55 alongside modern comparative bones.

BONES IN THE HEARTH PIT

The species distribution of the concentration of sooty fish remains (KM 25800:891, KM 25800:894, KM 25800:895 and KM 25800:927) found at the likely bottom of a hearth was different from that found elsewhere in the site (Figure 56). Most of the bones in the hearth pit were of large breams, which is similar to the fish pit at the Tervaniemi site in Taivalkoski, where all bones were of large breams. Species identifications of bream were made from the palatinum and hyomandibulare bones at both of these sites. This may also be the case, as in the Taivalkoski Tervaniemi pit, of a spawning flock catch of bream. In addition to cyprinids, some other species than cyprinids were also present in small numbers in the Veskankangas hearth pit, and some of the cyprinid bones were of smaller size fish. Therefore, the hearth was certainly in use for longer than just eating one bream flock. However, the possible bream flock indicates that the hearth was likely in use in the spring or early summer, during the spawning season. The presence of large pikeperch indicates summer fishing, as might also be the case at the Askola Siltapellonhaka site. In addition, because the bone material also included two winter-spawning species, burbot and four-horned sculpin, as well as numerous other fish species, the Veskankangas site can be considered year-round on the basis of the fish refuse.

8.2.3 Oulu Ylikiiminki Latokangas

The former municipality of Ylikiiminki, now part of the city of Oulu, is located in northern Ostrobothnia. The partly destroyed Stone Age site of Latokangas (Figure 57) is today a sandy ridge covered by a pine forest north of the Kiiminki River (Sarkkinen 1988). During the Stone Age, the Latokangas site was located on the shore of the Littorina Sea in a sheltered archipelago (Torvinen 2000).

Excavations at the Latokangas site took place in 1987-1990. Finds of burned bones were concentrated in years 1987 and 1988, of which in 1988 several small waste pits containing small burned fish bone crush were found (Sarkkinen 1988). The findings are listed under KM 23715 (1987) KM 24377 (1988). The Latokangas site is dated mainly to the Early Neolithic based on ceramics and shore displacement, but Middle and

Figure 57. Oulu Ylikiiminki Latokangas site at the time of occupation (74-78 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Late Neolithic ceramics have also been found in other excavation layers (Sarkkinen 1988; Torvinen 2000). I have not found any radiocarbon dating for this site, but Torvinen mentions, that the Early Neolithic Sär 1 –type ceramics, which were found abundantly at the Latokangas site, had been used in Finland ca. 6100-5500 BP (Torvinen 2000).

The excavation report does not mention anything about the use of screening, but the crushed fish bones had apparently been recovered mostly as such, with the surrounding sand. Pirkko Ukkonen has analysed the bones of both the 1987 and 1988 excavations, and has identified a number of seal (Phocidae) bones, as well as other mammals: beaver *(Castor fiber)*, dog *(Canis familiaris)*, pine marten *(Martes martes)*, mountain hare *(Lepus timidus)*, and of birds ducks (Anatidae), grouse (Tetraonidae), and eagle *(Aquila/ Halieëtus)* (Ukkonen 1996d; 1996e). The 1987 burned bone finds also included fish bone fragments: 223 of pike, 9 of perch, and 10 of cyprinids, seven of which were pharyngeal bone fragments (Ukkonen 1996d). In 1996, when Ukkonen analysed the bones, no fish vertebrae had been identified, and the reference bones for the cyprinid species

Species/ family	NISP	MNI
Esox lucius (pike)	372	16
Perca fluviatilis (perch)	215	7
Lota lota (burbot)	12	1
Coregonus lavaretus (whitefish)	20	1
Salmonidae (salmonids, including whitefish)	5	
Cyprinidae (cyprinids)	111	2
Total fish	**735**	

Table 14. Identified fish bones from the 1988 excavation at Oulu Ylikiiminki Latokangas.

were not yet available for species identification. Therefore, I first analysed cyprinid pharyngeal bones from the 1987 excavation and identified three of them as rudd (Nurminen 2003b). Of the 1988 bones, aside from vertebrae Ukkonen had not identified, small crumbs of fish bone were recovered from the waste pits. For this study, I have re-analysed all the 1988 excavation fish bones (Table 14, Nurminen 2010e). Unfortunately, three fish bone crumb piles still remained unidentified, as they were not found in the collections of the Finnish Heritage Agency and may have disappeared over time.

The bones were poorly preserved. Some bones of all identified species were of quite large individuals. All bones in the material were hard, more easily preserved skeletal parts, such as articular surfaces as well as vertebrae. Therefore, the high numbers of identifiable fragments per species in this material cannot be considered as a measure of a larger proportion of a species, nor can the minimum number of individuals in this material be considered a measure of species abundance, as a major part of the bones were vertebrae, and many of the proximal ends of the costae and lepidotrichiae. Nineteen percent of the pike bones (Figure 58) were teeth, and 75% of the perch bones (Figure 59) while 79% of the cyprinid bones (Figure 60) were vertebrae.

All the burbot and whitefish bones were vertebrae, and the five broken vertebrae fragments identified as salmonids could also be whitefish. Pieces of pharyngeal bones of cyprinids were so small that species could not be identified; thus, the only identified cyprinid species at the Latokangas site is rudd, from the 1987 material.

As the burned bone material included a range spring-summer spawning (pike, perch, and roach), autumn spawning (whitefish), and winter spawning (burbot) fish species, a year-round occupation at the site may be considered - on the basis of the fish remains, as like in the little older Late Mesolithic Ii Kuivaniemi Veskankangas site.

8.2.4 Simo Tainiaro

Simo is a municipality in Finland, located in the southwestern part of Lapland, on the border of northern Ostrobothnia, on the Gulf of Bothnia. The Stone Age Tainiaro site (Figure 61) is located on the south bank of the Simojoki River, on a sandy stoneless heath, on a terrace about 9 meters above the river´s present-day surface. The Tainiaro site is dated to the Early Neolithic based on shore displacement and the early comb ware ceramics found at the site (Wallenius-Saksanen 1984; Wallenius 1989c; 1990b; 1991b). The excavation reports mention sending carbon samples for dating (Wallenius 1989C; 1990b; 1991b), but the results are not attached to the files. Markku Torvinen writes about two AMS timings obtained from the Tainiaro site, yielding dates of 5940-5920 BP (Torvinen 2000).

Excavations at Tainiaro were carried out over four summers: 1984, 1989, 1990, and 1991 (Wallenius-Saksanen 1984; Wallenius 1989c; 1990b; 1991b). The findings are listed under KM 22398 (1984), KM 24925 (1989), KM 25797 (1990) and KM 26698 (1991). In addition to ceramics, dozens of graves, polished stone tools including also a partially polished fishing line

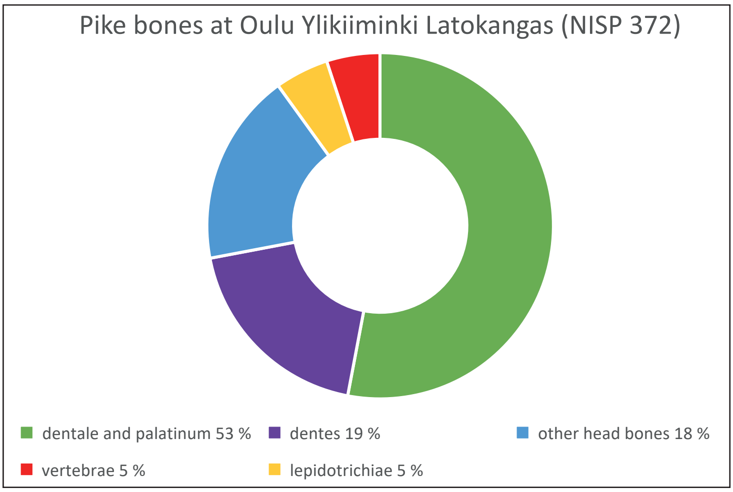


Figure 58. Anatomical distribution of pike bones at Oulu Ylikiiminki Latokangas.

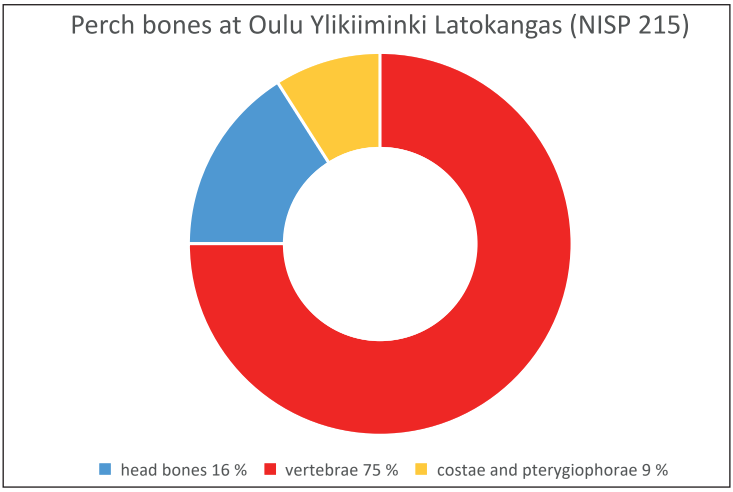


Figure 59. Anatomical distribution of perch bones at Oulu Ylikiiminki Latokangas.

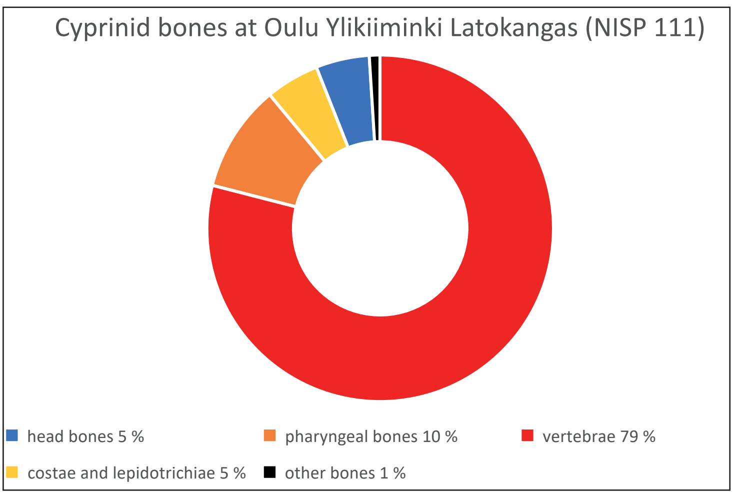


Figure 60. Anatomical distribution of cyprinid bones at Oulu Ylikiiminki Latokangas.

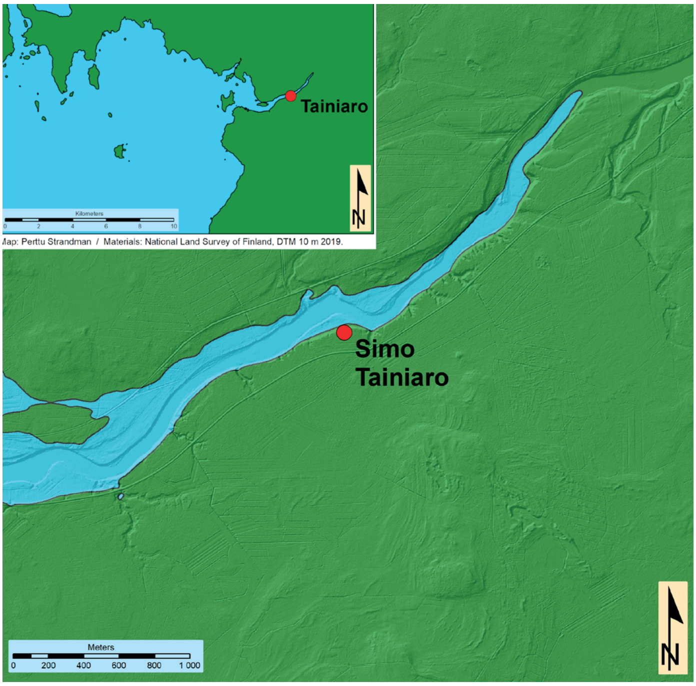


Figure 61. Simo Tainiaro site at the time of occupation (78 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

weight made of mica schist (KM 22398:614), and burned bones mainly of mammals were found during the excavations. There is no fish bone concentration at this site, and I have re-analysed the small number fish bones found at the site (Nurminen 2012l; 2012m; 2012n; 2012o) mainly because the majority of them are vertebrae which were not identified during previous analyses. There are no mentions of screening in the excavation reports, it is possible that not all fish bones have been recovered.

Pirkko Ukkonen has analysed the other bones. The burned fragments were mainly of seals (Phocidae). Mammals exploited at the site included beaver *(Castor fiber)*, elk *(Alces alces)*, reindeer *(Rangifer tarandus)*, pine marten *(Martes martes)*, and mountain hare *(Lepus timidus)*, and the family of ducks (Anatidae) among the birds (Ukkonen 1990c; 1990d; 1991d; 1996f).

Due to the limited number of fish bones, I combined the results of all the four excavations

Species/ family	**NISP**	**MNI**
Esox lucius (pike)	25	4
Perca fluviatilis (perch)	9	1
Lota lota (burbot)	2	1
Coregonus lavaretus (whitefish)	24	1
Salmo salar (salmon)	1	1
Salmonidae (salmonids)	80	
cf. *Carassius carassius* (possible crucian carp)	1	
Cyprinidae (cyprinids)	3	1
Total fish	**145**	

Table 15. Identified fish bones from Simo Tainiaro.

years. I identified a total of 145 fish bone fragments (Table 15).

The fish bones found at the Tainiaro site were poorly preserved and eroded. Relative to other Stone Age fish bone finds, an overwhelming majority of remains, (80% i.e. 116 out of 145 identified bone fragments) were vertebrae found in fragments. The reason for this could be excavation methods; that is, either not screening or screening with a large mesh size. In both cases, the diggers are likely to have recovered visually identifiable finds. Most people recognize fish vertebrae as fish, but other bones are unknown and may therefore be overlooked. In addition to the commonly encountered freshwater species, the Tainiaro assemblage also contained numerous salmonid vertebrae, of which 24 originated from whitefish and one from salmon. The rest of the vertebrae fragments of salmonids were too small for species identification, but by visual examination there were vertebrae of both whitefish and salmon or trout. In this material, the vertebrae of salmonids have survived, which was also the result of my burning experiment. One of the salmonid bones was the eroded articular surface of an articulare from a lower jaw.

Both identified burbot bone fragments were vertebrae. Five of the nine perch bones were also vertebrae, while four were head bones. As usual, the majority, 16 out of 25, of pike bones were fragments of the dentale and palatinum, and also one tooth. Five other head bones and three vertebrae were found.

Of the cyprinids, there were only four bone fragments in this material, one of the Weberian apparatus, one proximal end of a lepidotrich and two vertebrae, one of which, a complete specimen, strongly resembled that of a crucian carp. Cyprinid vertebrae are generally not identifiable to species, but I have noticed over the years, that the vertebrae of crucian carp are slightly different in appearance than that of the other cyprinid species. However, due to the small number of reference skeletons, species identification cannot be made with certainty, and would require further studies.

At the Tainiaro site, the Littorina Sea seems to have been a source of subsistence, but common freshwater fish species are also found in the bone refuse. Thus, people may not have consciously specialized in marine fish exploitation, but the local environmental conditions and the location of the site by a river bank were different from many other Stone Age sites and would have made marine food readily available, while traditional inland species could also have been caught when at hand. It is also necessary to remember the effects of the poor preservation of the bones and the possible shortcomings of the fish bone recovery process during the course of excavation.

In any case, as far as salmonids are concerned, this material proves that burned salmonid vertebrae preserve equally as well as the vertebrae of other species. This result is also supported by the result of my burning experiment, and it strongly suggests that the general lack of salmonid bones in the Stone Age is not due to the burning of the bones or the preservation rate of burned bones.

8.2.5. Virolahti Meskäärtty

Virolahti is the southeasternmost municipality of Finland. It is located in the southeast corner of Kymenlaakso province on the Gulf of Finland, at the Russian border. The Neolithic site of Meskäärtty (Figure 62) is to be found in the Järvenkylä area of Virolahti, 10 km west of Virolahti village (Mökkönen 2010). During the Stone Age, the site was located on the shore of a smaller bay on the eastern edge of a far inland bay, and was populated from 3700 to 2900 calBCE (Mökkönen 2016).

The Stone Age site of Meskäärtty covers a large embankment (c. 45 x 20 m) and includes a three-room house pit (Mökkönen 2008; 2010; 2011; 2016). The site was excavated over four summers: 2010, 2013, 2014 and 2015. Fish bones found during the first three years of excavations (2010, 2013-2014) are included in this study. The findings are listed under KM 38393 (2010), KM 39639 (2013) and 40383 (2014). In the first excavation of 2010, a pit full of burned bone was found on the outside of the northern wall of the dwelling. The bottom of the pit had a dense layer of silt and there was strong carbon concentration on the pit walls. In addition to

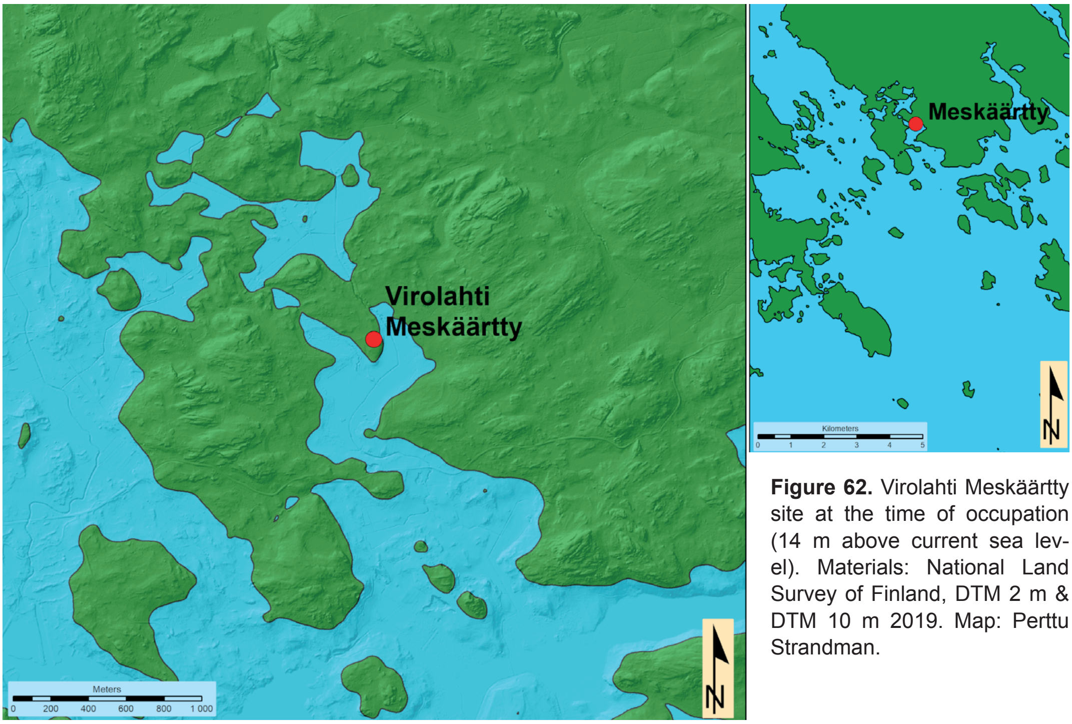


Figure 62. Virolahti Meskäärtty site at the time of occupation (14 m above current sea level). Materials: National Land Survey of Finland, DTM 2 m & DTM 10 m 2019. Map: Perttu Strandman.

Species/family	2010 NISP	2013 NISP	2014 NISP
Esox Lucius (pike)	350	59	41
Perca fluviatilis (perch)	2338	23	55
Percidae (percids)	2		
Lota lota (burbot)	2	3	1
cf. Lota lota (possible burbot)	1		
cf. Silurus glanis) (possible wels)	2		
cf. Gadus morhua (possible cod)	2		
Salmonidae (salmonids)	7		
Leuciscus idus (ide)	7		
L. idus/L. cephalus (ide/chub)	1		
Scardinius erythrophthalmus (rudd)	2		
Tinca tinca (tench)	1		
Cyprinidae (cyprinids)	358	8	6
cf. Cyprinidae (possible cyprinids)	4		
Total fish	3077	93	103

Table 16. Summary of identified fish bones for the three excavation years 2010, 2013, and 2014 from Virolahti Meskäärtty.

Species/ family	NISP	MNI
Esox lucius (pike)	350	25
Perca fluviatilis (perch)	2338	81
Percidae (percids)	2	
Lota lota (burbot)	2	1
cf. Lota lota (possible burbot)	1	
cf. *Silurus glanis* (possible wels)	2	
cf. Gadus morhua (possible cod)	2	
Salmonidae (salmonids)	7	1
Leuciscus idus (ide)	7	4
L. idus/ Leuciscus cephalus (ide/ chub)	1	
Scardinius erythrophthalmus (rudd)	2	2
Tinca tinca (tench)	1	1
Cyprinidae (cyprinids)	358	13
cf. Cyprinidae (possible cyprinids)	4	
Total fish	**3077**	

Table 17. Identified fish bones from the excavation year 2010 at Virolahti Meskäärtty.

the bones, some ceramics was also found at the bottom of the pit (Mökkönen 2010). Mökkönen (2010) supposes that the bone pit was originally a storage pit, which in the last stage of occupation served as a waste pit. Based on radiocarbon dating the last occupation phase of the northernmost room was between 3250-2900 calBCE, and the bark in the storage/waste pit outside the wall dates to 3350-3100 calBCE (Mökkönen 2013).

In addition to the bone pit, burned bones were also found in the cultural layers during every year of excavation. In all excavation years, all soil was screened with a 3.76 mm mesh (Mökkönen 2010; 2013; 2015), and the burned bones from the 2010 excavation bone pit were water-screened using a 1.5 mm mesh (Mökkönen 2010).

Kristiina Mannermaa analysed the mammal and bird bones of the 2010 excavation with the following identifications: reindeer *(Rangifer tarandus)*, ringed seal (*Pusa hispida)* and/or harp seal *(Pagophilus groenlandicus)*, common seals (Phocidae), beaver *(Castor fiber)*, mountain hare *(Lepus timidus)*, and divers (Gavia sp.) (Mannermaa oral statement 25.9.2019). I analysed the mammal and bird bones of the 2013 and 2014 excavations together with the fish, and identified ringed seal, common seals, beaver, mountain hare and ducks (Anatidae) (Nurminen 2015b; 2015c).

Quantities of burned fish bones were found during the 2010 excavation, not only in the bone pit but also in the cultural layers. The number of fish bones in the 2013 and 2014 excavations was smaller. A summary of the identified fish species is presented in Table 16, and below that are the results of the bone analyses by year of excavation.

Excavation year 2010

The burned bone material found at the Meskäärtty site in Virolahti was rich in well-preserved fish bones. In numbers, most of the bones were in a large bone pit. The material was clearly dominated by abundant quantities of perch bones. I identified a total of 3077 burned fish bone fragments from the material by species or family (Table 17, Nurminen 2012p).

The material was clearly dominated by perch bones (Figure 63), accounting for 75% of all

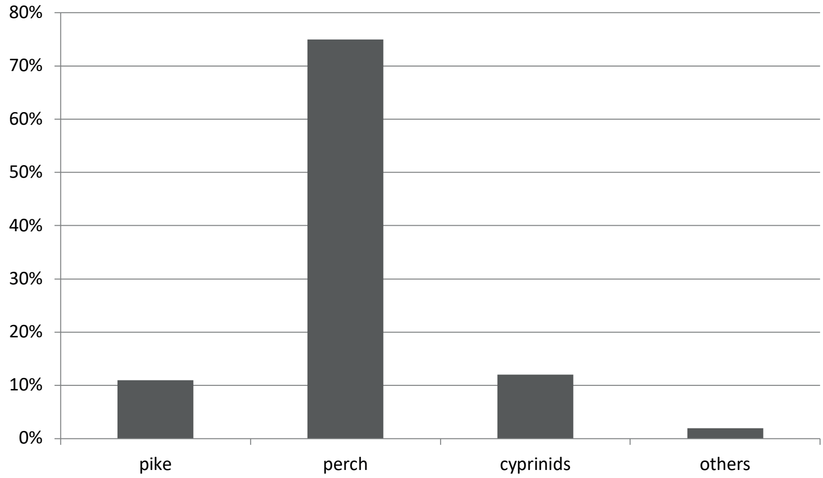


Figure 63. Identified fish bones from the excavation year 2010 at Virolahti Meskäärtty, in percentages by species/family.

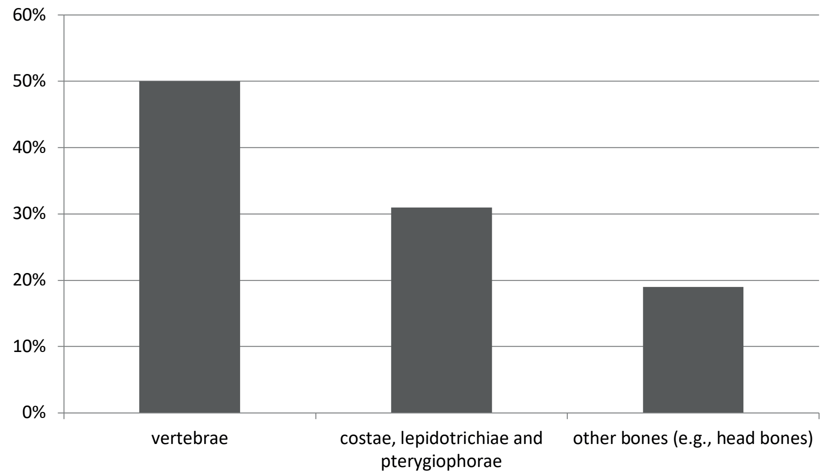


Figure 64. Distribution of perch bones at Virolahti Meskäärtty

identified fragments. Pike was represented by 11% and cyprinids 12% of the bones.

PIKE The numbers of pike bones in the Meskäärtty 2010 material are similar to Stone Age sites in general. There were bones from all parts of the fish; not only the head, but also pieces of vertebra pieces and the proximal ends of the ribs (costa) and fin rays (lepidotrichia).

PERCH The majority (75%) of all identified fish bones in Meskäärtty belonged to perch. Identified perch bones included bones of all parts of the fish skeleton. Fifty percent of all identified perch bones were vertebrae and 31% were the proximal ends of costae, lepidotrichiae, and pterygiophorae (Figure 64). Thus, the total number of the above bones of all perch bones is 81%. The result shows the importance of identifying these bones.

Perches in Meskäärtty have a broad size distribution, but burned and broken bone fragments cannot accurately estimate fish size. There were fish of all sizes, from small to huge. I have looked at the annual growth rings of the largest percid vertebrae under a microscope to compare them to perch and pikeperch vertebrae. Pikeperch grows faster and has larger growth rings in the vertebrae. The big vertebrae in Meskäärtty had lots of rings at short intervals, and therefore they most likely belong to perch. The Meskäärtty bone material also did not contain any other pikeperch bones.

BURBOT, WELS, AND COD Only two burbot vertebrae were found. The presence of burbot in Stone Age bone material usually indicates winter fishing. However, this is not the case with these bones. The small vertebrae of burbot are from young fish, with only two annual rings. Young burbots move along the coastline all year round.

Two rib ends identified as those of wels are uncertain. These bones were very small, and since no other wels bones were found, the identification cannot be considered completely certain. However, the existence of the wels is entirely possible, as a few wels bones have been found in Finland in Stone Age contexts. If it actually was a wels, the fish was quite small. Burbot and wels are freshwater fish, but can also manage in brackish water of low salinity.

Among the marine fish remains, there were also two proximal rib ends of cod. They were large in size. The reference collection of the Finnish Museum of Natural History LUOMUS contains only one incomplete skeleton of a small cod, and for some reason it has been difficult to obtain larger reference specimens in Finland. Cod is rarely sold even in markets. I have marked the cod as uncertain, because there were no other cod bones in this material.

SALMONIDS Seven of the identified vertebrae belonged to salmonids. The burned Stone Age salmonid bone material in Finland consists mainly of whitefish vertebrae, and have been found all over the country except for the northern parts so far. However, the salmonid vertebrae in Meskäärtty differed in appearance from the normal burned whitefish vertebrae. The vertebrae originated from small fish. They were slightly darker in overall tone and slightly more sunken at the centre. The species of these bones could not be identified with certainty, but I would consider it possible that they belong to trout. Trout lives in both fresh and brackish water.

CYPRINIDS The number of cyprinid bones in the Meskäärtty 2010 material are similar to other Stone Age sites in general. Three specific species of cyprinids were found in Meskäärtty: ide, rudd, and tench. One of these bones was the palatinum of a large ide and the others were fragments of pharyngeal bones. Despite the small total number of fragments, the minimum number of individuals of ide was four and of rudd two.

THE BONE PIT The number of fragments recovered from the bone pit (KM 38393:1111, :1112, :1201, :1202, :1203, :1298, :1299, :1300, :1301, :1302, :1303, :1304 and :1363) differed slightly from the overall results (Figure 65). The total number of identified fish in the bone pit is 2233 fragments, which is 73% of the total identified 3077 fish remains. Of these, 3.5% were of pike, 84% of perch, 11.5% of roach and 1% of others.

There are clearly fewer pike remains (80 fragments) in the bone pit than in the material as a whole. Thus, most of the pike bones are scat-

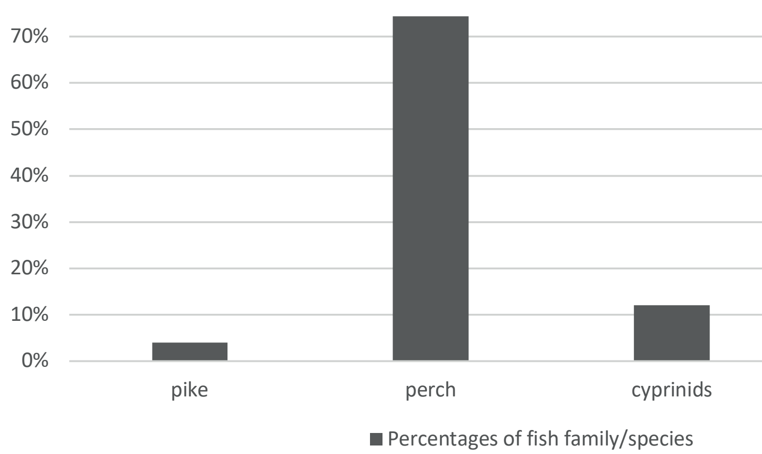


Figure 65. Fish family/species percentage distribution in the Virolahti Meskäärtty bone pit.

Species/ family	NISP	MNI
Esox lucius (pike)	59	3
Perca fluviatilis (perch)	23	2
Lota lota (burbot)	3	1
Cyprinidae (cyprinids)	8	2
Total fish	**93**	

Table 18. Identified fish bones for excavation year 2013 at Virolahti Meskäärtty.

tered along the cultural layers of the excavation area as single fragments. This is typical of Stone Age sites. Perch (1874 fragments), on the other hand, is relatively more frequent in the pit than in the overall material. The proportion of cyprinids is approximately the same in the bone pit and for the overall material. The pit also contained all identifiable bones of ide, rudd, and tench, possible wels and cod ribs, and five salmonid vertebrae. Most of identified fish species in the Meskäärtty bone material come from the bone pit, which may be in addition to bones found in the pit concentration due to the fact that these bones were screened with a denser screen.

Excavation year 2013

The bones of the 2013 excavation were few, fragmented and fragile. The identified fish taxa (Nurminen 2015b) are shown in Table 18.

There were few fish bones, mostly small fragments. Pike remains mainly originated from bones of the jaw. In addition to the bones of the head, the pike bones contained two pieces of vertebrae and six proximal ends of fin rays (lepidotrichiae). Most of the perch bones, 16, were vertebrae, but there were also head bones and one proximal end of a rib (costa). The cyprinid bones were a piece of jawbone, fragments of the pharyngeal bone and a couple of vertebrae. Burbot bones were one piece of a vertebra and two pieces of bone from the jaws (dentale and articulare), with at least the articulare being from a large fish.

Excavation year 2014

The bones recovered during the 2014 excavation were similar to those of the 2013 excavation: fragmented and fragile. The identified fish taxa (Nurminen 2015c) are shown in Table 19.

There were plenty of burned fish bone fragments, but they were mostly very small and also originated from small individuals. Most of the fragments were vertebral or rib/fin ray fragments, for which no species identification was possible. The bones of pike were mainly of the jaw. Some pike jawbones and one vertebra came from large specimens, while others were of small pikes. Most perch bones were vertebrae, but there were also bones of the jaws. The cyprinid fragments

Species/ family	NISP	MNI
Esox lucius (pike)	41	4
Perca fluviatilis (perch)	55	3
Lota lota (burbot)	1	1
cf. *Rutilus rutilus* (possible roach)	1	
Cyprinidae (cyprinids)	5	1
Total fish	**103**	

Table 19. Identified fish bones for excavation year 2014 at Virolahti Meskäärtty.

consisted of pharyngeal bones and a couple of vertebrae. One pharyngeal bone fragment is possibly of roach. Burbot were represented by a small fragment of a precaudal vertebra, which did not allow the estimation of age, i.e. determining the sexual maturity of the individual.

Reflections on the bone pit material and fishing methods at Meskäärtty

The number of perch makes this bone pit interesting. Could the fishing or treatment of different species have been selective? Do the fishing methods explain the predominance of perch, or is it due to natural conditions? Species distributions of fish identified in inland Stone Age habitats can generally be easily explained by the lushness of the lake environment or a proximity to flowing water, assuming that the fishing was practiced at the coastline. Virolahti is located on the coast of the Gulf of Finland, albeit on the shore of a long bay, and the natural conditions at the seaside are different from the normal lake conditions of inland habitats, although the salinity of the seawater was probably quite low and there were probably sources of fresh water nearby.

The simplest interpretation is that the community fished for what was available, without selectivity. There would hardly have been any fishing out at sea, nor is there any evidence of it within the bones. If the fishing had happened farther from the shore, there would have been more bones of larger fish, such as trout, cod, and perhaps pikeperch. The few small vertebrae of burbot in this material indicate not winter fishing but shoreline fishing, although the articulare bone from the 2013 excavation was of a larger burbot, which would have most probably been caught in winter. The entire composition of the fish bone material could be explained for instance by shoreline fishing using a simple seine, weir, or trap, and this could have been a year-round activity. It is possible that the nearby sea was naturally rich in perch of different sizes. Perch still thrive on the southern coastline of Finland. Inland sites tend to have larger numbers of cyprinids, and most of the cyprinid fish thrive in very lush lake conditions. Perch, on the other hand, have adapted well to brackish water.

It is noteworthy that the bone pit, where most perch bones were found, was screened with a much denser screen, 1.5 mm mesh, than the bones in the cultural layers. My screening test proves that a denser screen size produces a clearly different result than the commonly used 4 mm screen when recovering fish bones. With a denser screen, the proportion of smaller fish, perch and small cyprinids, increases significantly. Therefore, in this waste pit, we may have come closer to the actual species distribution of fished species than in any other sites in this chapter. For comparison, the Kuhmo Vasikkaniemi bone pit was also carefully water-screened, but not all the small vertebrae of that site have been counted. We researchers can often make a difference in what kind of finds are recovered from excavations and the quality of results thus made possible.

8.3 Summary and comparison of fish bone analyses

This study includes 10 archaeological sites, half of which were in inland lake regions during the Stone Age and half on the Littorina Sea coast. The time range of these sites is large, from the Mesolithic to the end of the Neolithic. The most important general feature is that the same species of fish, mainly pike, perch, and cyprinids, occur almost everywhere. Whitefish are less common in the Mesolithic sites but otherwise also common. When this result is complemented by other fish bone analyses of Stone Age fish bone refuse (Table 1 in chapter *5.2 Stone Age fish bones in Finland*), it can be noted that this general uniformity covers the whole country and the entire Stone Age.

8.3.1 Fish species

The summary of the identified fish bones from the sites in this study is presented in Tables 20 and 21.

SITE	Pike NISP	Perch NISP	Pikeperch NISP	Burbot NISP	Whitefish NISP	Cyprinids NISP	Others
Kuhmo Vasik-kaniemi (M)	833	523	-	4	72	470 rudd, chub, roach, ide	-
Taivalkoski Tervaniemi (M)	-	-	-	-	-	886 bream 41 fr	-
Ranua Kultis-almi (N)	182	37	-	-	5	23	-
Posio Kuorik-kikangas (LN)	893	485	-	5	75	524 roach, ide	-
Puumala Kärmelahti (LN)	256	93	-	-	13	56 ide	-

Table 20. Inland sites, summary of identified fish bones. M = Mesolithic, N = Neolithic, LN = Late Neolithic.

SITE	Pike NISP	Perch NISP	Pikeperch NISP	Burbot NISP	Whitefish NISP	Cyprinids NISP	Others
Askola Siltapellon-haka (MM)	22	4	25	-	-	116 bream, asp?	salmon/ trout 1
Ii Kuivanie-mi Ves-kankangas (LM)	746	101	23	2	48	516 e.g., bream, roach	fourhorned sculpin 1, salmon/ trout
Oulu Ylikiiminki Latokangas (EN)	372	215	-	12	20	111	-
Simo Taini-aro (no pit) (EN)	25	9	-	2	24 (+ 80 salmonids)	4	salmon
Virolahti Meskäärtty (N)	450	2416	-	7	-	383 ide, rudd, tench	wels? cod? trout? roach?

Table 21. Littorina Sea coastal sites, summary of identified fish bones. MM = Middle Mesolithic, LM = Late Mesolithic, EN = Early Neolithic, N = Neolithic.

Pike and perch, the two Finnish “basic fish”, are found in all other sites except the Mesolithic Taivalkoski Tervaniemi. The Tervaniemi bone pit was extraordinary in this regard, as it most obviously was the remnant of a meal made from a large spawning flock of breams. Cyprinids were present at all sites. The same kind of remnants of a spawning flock of breams that we saw in Tervaniemi was also found in the Late Mesolithic Ii Kuivaniemi Veskankangas site, though some other fish were also found in the Veskankangas bone pit.

Pikeperch was present in the two Mesolithic Littorina Sea coastal sites, Askola Siltapellonhaka and Ii Kuivaniemi Veskankangas. Askola is located in the south, on the shore of the Gulf of Finland, while Ii is on the northern shores of the Gulf of Bothnia. The pikeperch range extends nowadays throughout the coastal areas of Finland, and apparently it has been the same at least in, and perhaps since, the Mesolithic. Pikeperch is quite rare in the Stone Age bone remains, and most of the identified bones are from large individuals, as in this study. This may be due to the pikeperch´s lifestyle. Pikeperch thrives in shoreline areas, mainly during the spawning season and the subsequent growing season, both in summertime. The large spawning pikeperches must have attracted the shoreline fishermen. At other times of the year it is harder to catch the pikeperch, as fishing them requires going to the deep water, as is the case still today.

While pikeperch is considered a summer fish, burbot is a winter fish. Since burbot can be caught mainly during the winter spawning season, its presence indicates winter fishing. Burbot bones were found at two inland sites, the Mesolithic Kuhmo Vasikkaniemi and the Late Neolithic Posio Kuorikkikangas, as well as in four of five of the Littorina Sea coastal sites dating from the Late Mesolithic to the Neolithic. I have made a small case study of the Stone Age burbot finds, more of that in chapter 9.1 *Case study 1: Burbot (Lota lota) bones and winter fishing*.

Whitefish bones were identified at all other inland sites except in the Taivalkoski Tervaniemi bream pit. Whitefish was present in three Littorina Sea coastal sites: Ii Kuivaniemi Veskankangas, Oulu Ylikiiminki Latokangas, and Simo Tainiaro, all of which are located on the northern shore of the Gulf of Bothnia. The two coastal sites lacking the whitefish, Middle Mesolithic Askola Siltapellonhaka and Neolithic Virolahti Meskäärtty, are located in the south, on the shore of the Gulf of Finland. Whitefish has a variety of different lifestyles that can even be specifically local (Yrjölä et al. 2015). It is possible that during the Stone Age, whitefish lived in deeper waters in the Gulf of Finland, beyond the reach of the fisherman, than those of the Bothnian Bay or inland waters. There is no definite answer to this. In addition to the differences in local whitefish lifestyle, coincidence and taphonomical factors may also have contributed to the lack of whitefish remains recovered on the southern coast.

In the inland lakeside sites, the variety of fish species was smaller than in the coastal sites. The identified fish in inland sites were pike, perch, burbot, whitefish, and cyprinids.

The same freshwater fish were also found in the Littorina Sea coastal sites, with the Mesolithic pikeperch bones and a small hint of salmon, as well as one Late Mesolithic four-horned sculpin vertebra in Ii Kuivaniemi Veskankangas and possible traces of wels, cod, and trout in the Neolithic Virolahti Meskäärtty site. All of these differences, which are not big, can be explained by environmental conditions, the lifestyle of the fish or the excavation methods. In Meskäärtty, where huge numbers of perch bones were found, a denser screen was used in sieving the bone pit. In addition to that, the coast of the Gulf of Finland as a living habitat is favourable for perch.

8.3.2 Anatomical distributions of bones

When bones are burned and then are deposited underground for thousands of years, great bone losses occur. As shown in the burning experiments (see chapter 7.1.1 *Burning experiments*), some individual bones are destroyed easily during burning, while others remain more easily identifiable.

The results are also influenced by human activity during the excavation and research project. The large mesh commonly used in excavations produces a distorted picture of the fish species used at the site. In addition, vertebrae of fish have not been identified at all in the older bone analyses. I made a summary of the anatomical distributions of identified bones from the applicable sites in this study by species/family, to find out how the bones of different species survive.

Of the inland sites, the bones from the Kuhmo Vasikkaniemi site are not included in this comparison because all the vertebrae fragments have not been counted, and neither are the bones of the cyprinid bone pit of the Taivalkoski Tervaniemi site included. Of the Littorina Sea coastal sites, I left out the bones from the Askola Siltapellonhaka and Simo Tainiaro sites because of the small number of bones and the bone abrasion/erosion, as well as poor preservation. For the Ii Kuivaniemi Veskankangas bones, I made

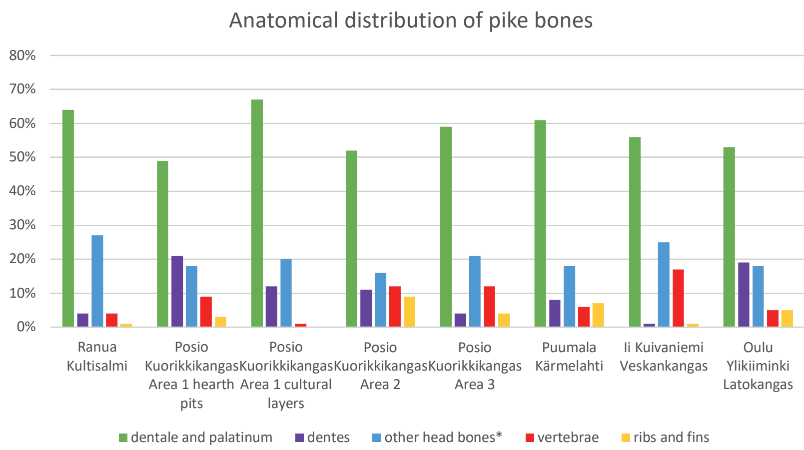


Figure 66. Summary, anatomical distribution of pike bones. * head bones, see chapter *6.1 Skeleton of a fish*.

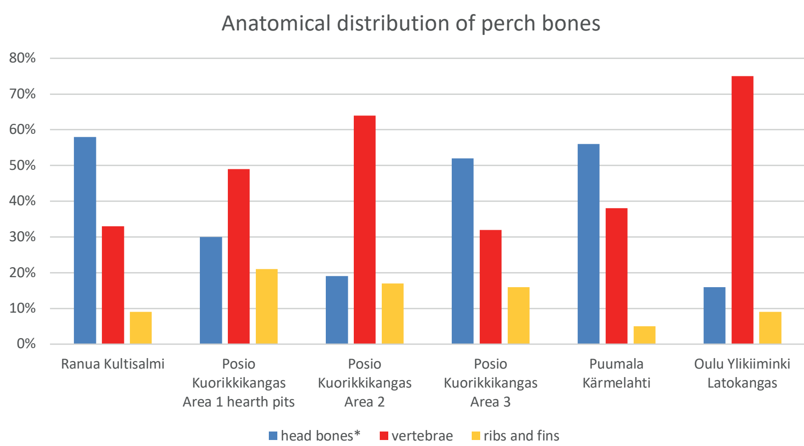


Figure 67. Summary, anatomical distribution of perch bones. * head bones, see chapter *6.1 Skeleton of a fish*.

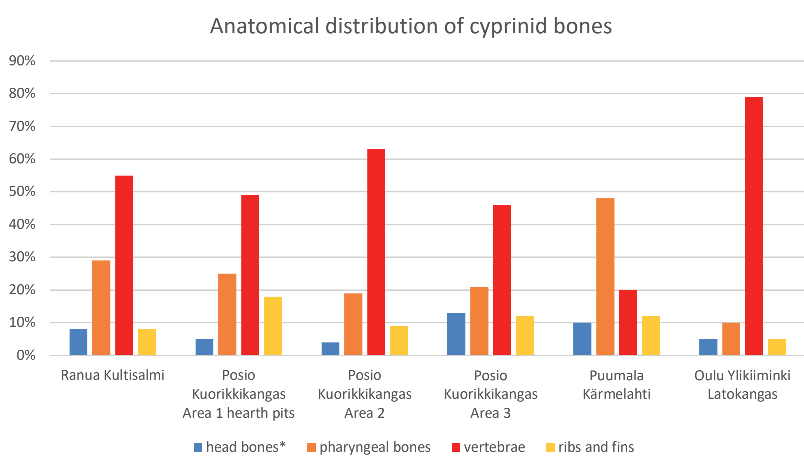


Figure 68. Summary, anatomical distribution of cyprinid bones. * head bones, see chapter *6.1 Skeleton of a fish*.

an anatomical distribution only for the pike bones in the cultural layers, since most of the other bones were in the cyprinid bone pit. The bone distribution for the Virolahti Meskäärtty site was extraordinary because of the predominance of perch bones, and therefore the results were not suitable for this comparison.

The summary tables of the anatomical distribution of the identified bones of the most common species (pike, perch, and the family of cyprinids) are shown in Figures 66, 67, and 68. All identified whitefish bones at all sites were vertebrae.

As expected, pike bones with teeth, i.e. the dentale and palatinum bones, make up a clear majority of all identified pike remains. The second largest group are the other head bones. Teeth are also well preserved, but finding them requires fine screening, as does the recovery of ribs and fin rays (Figure 66). The excavation reports for many sites do not mention the screening method utilized. In addition, there are surprisingly few pike vertebrae, considering the fact that they are often quite large in size and survived well in my burning experiment.

There are major differences in the anatomical distribution of perch bones between sites. Some assemblages are dominated by head bones, others by vertebrae (Figure 67). This must be connected to the excavation methods and screening processes. As information on screening is not available for all sites, there are still uncertainties. However, we can compare these results with the Virolahti Meskäärtty fish pit, which was screened with a dense 1,5 mm mesh, and where 50% of all identified perch bones were vertebrae and 31% were the proximal ends of ribs and fin rays. This indicates that the denser mesh increases the numbers of vertebrae, as well as ribs and fin rays, at least in well-preserved assemblages. It should also be noted that, despite the differences, the proportion of perch vertebrae at all sites was still at least 30%.

The number of vertebrae dominates the identified bones of the cyprinids (Figure 68). Only in Puumala Kärmelahti is this not the case. The reason must be taphonomical, or connected to the excavation methods. Closer to 13 000 fragments of extremely poorly preserved and strongly eroded burned bones were recovered from the Puumala Kärmelahti site, and the screening was done with a large mesh size; yet the total number of identified cyprinids was only 55 fragments. It is possible that fishing has focused on small individuals in Kärmelahti, and most of the recognizable features of the bones were already destroyed by burning.

These comparisons of bone anatomical distributions clearly show how burned bones of different fish species remain identifiable in different ways. The identification of all bones is important, as otherwise some species, such as whitefish, may not be identified at all, and the meaning of some others can be misunderstood. Because of the uneven rates of preservation of the burned bones of different species, the varying excavation and recovery methods employed at different sites, and the purely coincidencal nature of finding bones, the relative distribution and utilization of these fished species during the Stone Age remains unclear. It is also possible that only a part of the fish waste was thrown into the fire in the past, perhaps because of the different uses for some fish species, or for reasons that modern human cannot even imagine. Nevertheless, we can argue with certainty that pike, perch, whitefish, and cyprinids were the most important fish for Stone Age subsistence, although we cannot suggest that any of these were more important than the others.

9 Fish case studies

Over the years, as I analysed Stone Age fish bone materials, the identifications of some fish species raised deeper questions. One of the more interesting species is burbot, which has a different lifestyle from the other fish species that are currently common in Finland. There is also other interesting observations to be made about the cyprinid species. To delve deeper into these topics, I conducted two case studies, described below.

Figure 69. Burbot *(Lota lota)* caught 12 February 2016. Male, 54 cm, 1.138 kg, 6-years-old. Photo: Tero Nurminen

9.1 Case study 1: Burbot (*Lota lota*) bones and winter fishing

Winters in Finland are cold and snowy, and the lakes and rivers freeze over. Winter fishing under the ice has been widely practiced during historic times (Lappalainen & Naskali 1995; 1999; Lehtonen 2007; see also chapter *4.2.6 The significance of ice fishing*). It requires different methods than open water fishing. For instance, perch and other small fish are easy to catch by jigging through a hole in the ice. Simple fishing methods such as targeting individual fish with spears, clubs, or fish gigs are usable even in wintertime. When the lake freezes over the dissolved oxygen content of the water changes. Because of this the fish, especially burbots and pikes, stay in the shallow waters right under the ice, where they are easy to catch (Järvisalo 2004).

9.1.1 Burbot and the history of burbot fishing in Finland

In this chapter I will introduce the lifestyle of burbot and the history of burbot fishing in Finland.

9.1.1.1 Burbot

Burbot (Figure 69) is a fresh-water fish belonging to the family Gadidae. Today, burbot is common throughout Finland. The fish is active at nighttime. One interesting trait of burbot is its unique spawning-time in mid-winter, when it is also active during the day. Burbots spawn under the ice in waters close to the shore, where they are easy to catch. The rest of the year adult burbots stay in the deep waters of open lakes, although young and small burbots sometimes swim near the shore even in summertime (Lehtonen 2007).

9.1.1.2 Burbot fishing and use

Today, burbot is considered a very delicious and wholesome fish food (Lehtonen 2007). During historical times, it was often caught under the ice with a special triple-pointed gorge, a wooden hook called a "*nokkanen*" in Finnish (see *4.2.2 Angling with hooks and lines)*. This fishing method was probably already common in the Stone Age (Halonen & Pennanen 2015)**.** Burbots have also sometimes been captured in fish traps lowered down into the water through a hole in the ice (Sirelius 2009). Even today, burbots are often caught under the ice using hooks (Jussila 2007), and can also be captured with bait even early in the spring, right after spawning. Today in Finland burbots can be bought from the supermarkets only in their spawning-time in January and February.

It is also possible to catch burbots using nets when fishing for other species in the middle of an open lake during the late autumn. This kind of large-scale net fishing is unlikely to have been used during the Stone Age in Finnish lakes (Nurminen 2006). The density of the human population at that time was low, and it would have been easier simply to fish for pike and smaller fish such as perch and roach from the lakeshore.

The fish remains discarded at Stone Age dwelling sites support this assumption.

Burbot skin is also well known as an excellent raw material for manufacturing small objects such as purses (Berg 1984). Some small-scale exchange between neighbours was possible already in the Stone Age. If so, the fish must have been sold fresh. Finland is – and has always been, already in the Stone Age – full of lakes that are full of fish easy for anyone to catch. Therefore, I consider it obvious that every family fished from the nearest lake.

9.1.2 Materials and methods

9.1.2.1 Bone analyses

Over the past years I have analysed numerous burned animal bone finds from archaeological excavations all over Finland. These bones have been found in the cultural layers of Stone Age settlements. The research method has been comparative osteological analysis. It is based on the accurate identification of bone morphology.

When I was pursuing this work, I gradually started to pay more attention to the burbot bones, which were not numerous but were found at surprisingly many dwelling sites. Before my studies, only five burbot bones had been identified at Stone Age sites in Finland, and considering this small number the fish had not been considered relevant.

Although the number of burbot bones was rather small in all studied assemblages, many other animals were found in association with burbot bones, and in much higher frequencies. There are seals (Phocidae), as well as wild terrestrial mammals such as elk *(Alces alces),* reindeer *(Rangifer tarandus),* beaver *(Castor fiber)*, fox *(Vulpes vulpes)*, pine marten *(Martes martes)*, mountain hare *(Lepus timidus)*, red squirrel *(Sciurus vulgaris)*, and otter *(Lutra lutra)*. The birds identified included capercaillie *(Tetrao urogallus)*, black grouse *(Tetrao tetrix)*, willow grouse *(Lagopus lagopus)*, diver/ red-throated diver (*Gavia arctica/ Gavia stellata)*, and various species of wild ducks (Anatidae). Aside from burbot, there were also many other fish, including pike, perch, pikeperch, whitefish, and various species of cyprinids. (Fortelius 1980; Nurminen 2003c; 2008; 2013; 2014; 2015a; Ukkonen 1995b; 2004b).

9.1.2.2 Age-determination

The most common means of used for age-determination of fish utilize fish scales and otoliths. Unfortunately, neither of these have been preserved among the burned fish remains of any fish species in Finland. Burbot scales would also be too small for age-determination, and therefore only burbot otoliths are normally used for this purpose (Raitaniemi et al. 2000). When trying to determine the possibility that burbots were caught in the winter, it is essential to know whether the fish remains belonged to a sexually mature adult fish or not. In the absence of otoliths, I used vertebrae for age-determination. Similarly to scales and otoliths, vertebrae also have year-rings (Raitaniemi et al. 2000, see also *8.1.1 Kuhmo Vasikkaniemi SW*). This method may not be as accurate as studying burbot otoliths, but it does provide a direct measure of fish ages (Nyberg 2012 pers. comm.).

When using burned vertebrae for age-determination, it is important to remember that the outermost layer, which could still have been quite soft, may have been consumed during the burning. However, this is not a crucial shortcoming when trying to trace the minimum age of the fish.

9.1.3 Results and discussion

9.1.3.1 Stone Age burbot finds

In this study I focused on the Stone Age burbot finds in Finland. I have recently found burned burbot bones at many Stone Age settlements, almost throughout the entire country with the exception of northern Lapland. Burbots spawn in the mid-winter in shallow waters near the shore. During the rest of the year mature burbots stay in the deep waters of open lakes. Therefore, burbot finds seem to be related to winter fishing during their spawning time in January and February.

To date, burned burbot bones have been found at 16 Stone Age sites in Finland (Figure 70). The Seinäjoki and Eurajoki bone material was

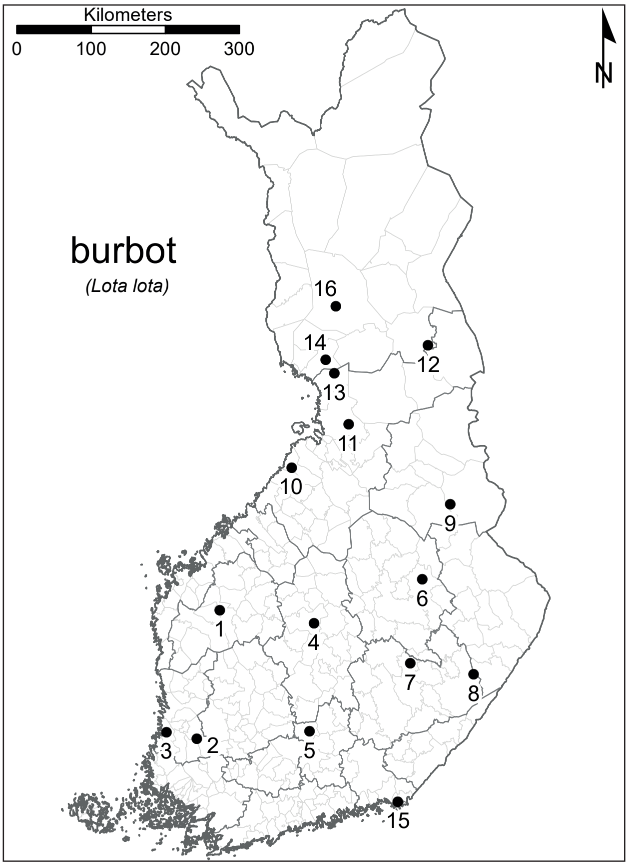


Figure 70. Stone Age burbot finds from Finland.
1. Seinäjoki Aapraiminmäki,
2. Kokemäki Kraviojankangas,
3. Eurajoki Etukämppä,
4. Saarijärvi Uimaranta,
5. Padasjoki Leirintäalue,
6. Kuopio Nilsiä Lohilahti,
7. Joroinen Kanava,
8. Savonlinna Kerimäki Martinniemi,
9. Kuhmo Vasikkaniemi,
10. Raahe Pirttihauta,
11. Oulu Ylikiiminki Latokangas,
12. Posio Kuorikkikangas,
13. Ii Kuivaniemi Veskankangas,
14. Simo Tainiaro,
15. Virolahti Meskäärtty,
16. Rovaniemi Koskenniska.

Materials: National Land Survey of Finland, Administrative borders 2019. Map: Perttu Strandman

analysed by Pirkko Ukkonen (Ukkonen 1995b, 2004b) and the Kokemäki bones by Mikael Fortelius (Fortelius 1980**.** I have analysed all the other burbot bones, i.e. those from Saarijärvi, Padasjoki, Kuopio, Joroinen, Savonlinna, Kuhmo, Raahe, Oulu, Posio, Ii, Simo, Virolahti, and Rovaniemi (Nurminen 2002; 2004c; 2003a; c; d; 2004b; 2006; 2008; 2010a; e; 2011; 2012g; m; p; 2013; 2014; 2015a-c).

The number of burbot bones so far recovered is only 98 fragments, found at all the Stone Age sites throughout Finland that were the subject of osteological studies. This does not in itself mean that burbots were rare. Drawing such conclusions from burned fish bones is difficult, because so many of the bones are destroyed during burning (Nurminen 2016).

Burbot bone finds are mostly vertebrae but some head bones have also been found (Figure 71). I have analysed the fish ages using the year-rings of vertebrae whenever possible (Figure 72). Many of the vertebrae fragments were too small for age-determination. Male burbots start taking part in spawning at the age of 2-3 years, females at the age of 3-4 years. If the analysed vertebra belonged to a 4-year-old or older burbot, it is reasonable to suggest that the individual was already spawning-age, that is mature (Nyberg 26.9.2012 personal e-mail).

All of the burbot finds to date are presented in Table 22. When the bone fragments were too small for age-determination, I have estimated the size of the fish by comparing the fragment to the bones of a modern, 5+ -years-old burbot reference skeleton. In this table the determination “adult” or “large individual” thus means that the size of the burned fragment is at least as large as the corresponding element in this reference skeleton.

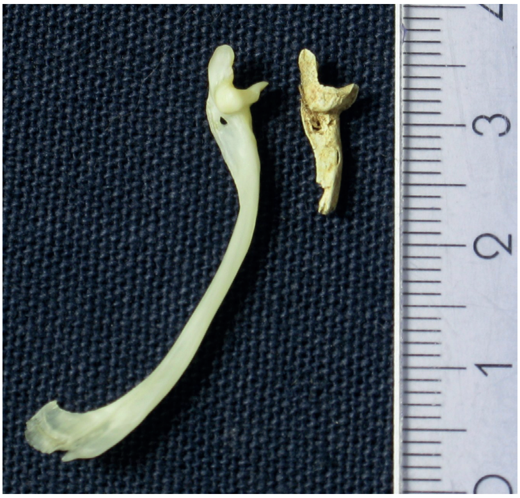


Figure 71. Maxillare from Rovaniemi Koskenniska, excavated on 2013 (right). Reference bone from a burbot age 5+ (left). Photo: Tero Nurminen

Figure 72. Examples of vertebrae used for age-at-death estimates. Age 7+ from Saarijärvi (upper left) age 9+ from Savonlinna (upper right), age 7+ from Posio (lower). Photo: Tero Nurminen

Location	Burned burbot bone fragments	Fish ages estimated from vertebral annuli
Seinäjoki Aapraiminmäki	articulare, praemaxillare	adult individual
Kokemäki Kraviojankangas	2 vertebrae	small fragments
Eurajoki Etukämppä	dentale	adult individual
Saarijärvi Uimaranta	vertebra	7+
Padasjoki Leirintäalue	cleithrum, 5 vertebrae	adult individual
Kuopio Nilsiä Lohilahti	cleithrum, basioccipitale, 17 vertebrae	small fragments
Joroinen Kanava	quadratum, cleithrum, 5 operculare, 9 vertebrae	3+, 4+, 6+
Savonlinna Kerimäki Martinniemi	2 vertebrae	7+, 9+
Kuhmo Vasikkaniemi	4 vertebrae	3+, 4+
Raahe Pirttihauta	articulare, 2 quadratum, 4 cleithrum, 10 vertebrae	small fragments
Oulu Ylikiiminki Latokangas	12 vertebrae	4+, 5+, 6+
Posio Kuorikkikangas	maxillare, 4 vertebrae	5+, 6+, 7+ and one 1/3 fragment from a very large individual
Ii Kuivaniemi Veskankangas	vertebra	5+
Simo Tainiaro	vertebra	small fragment
Virolahti Meskäärtty	2 articulare, 4 vertebrae	2+ and one articulare from a large individual
Rovaniemi Koskenniska	dentale, maxillare, vertebra	adult individual

Table 22. Burbot finds and ages.

9.1.3.2 The relevance of burbot in Stone Age Finland

Burbot differ from the other fish species in Finland in their seasonally unique winter spawning time. Although the number of identified burbot bone finds is only 98 to date, the widespread occurrence in Finland suggests that this deep-water fish was more important than was previously recognized. Fishing is often considered to have only taken place when lakes are open (not frozen). Burbot bones were found along with the remains of many other fish species within the same contexts. Pike and perch can be caught year-around, and also under the ice, but for the most part large burbots can only be caught in winter. Therefore, the evidence of burbot finds suggests that fishing may have been possible from the lakeshores throughout the year.

9.1.4 Conclusions

Most of the burbot bone finds derive from adult, sexually mature, spawning-age fish. The burbot vertebrae certainly originated from smaller individuals only at Meskäärtty in Virolahti, a settlement located on the Baltic coast. Even there, one head bone (articulare) was found that belonged to a larger fish. The fish remains at Virolahti were plentiful and mostly from smaller fish; 75% of all identified bones belonged to perch (Nurminen 2012p). The fishing strategies practiced at Virolahti may have been different from those practiced at inland sites.

Burbot finds also seem to be uniformly present at other sites, represented by bones from large, sexually mature fish all over the country. This suggests that burbot fishing mainly took place during the winter in prehistoric Finland. However, adult burbot bones were found in the same contexts with spring- and summer-spawning fish such as pike, perch, and cyprinids. Although pike, perch, and many cyprinids can be caught near the shoreline all year round, their presence suggests that these sites were not just winter sites, and therefore may indicate year-round occupation. This is an interesting result, and it challenges the often widespread belief that life in the Stone Age was predominantly mobile, which is why many Stone Age settlements have been considered to be temporary camps (e.g., Pennanen 2009; Halinen 2015). As an additional element to consider, five of the sites that yielded burbot bones (Saarijärvi Uimaranta, Joroinen Kanava, Savonlinna Kerimäki Martinniemi, Posio Kuorikkikangas (Pesonen 2002) and Virolahti Meskäärtty (Mökkönen 2008; 2011)), also had house pits, which is generally considered to be indicative of permanent settlement.

9.2 Case study 2: Cyprinids in the Stone Age

Cyprinids form the taxonomically most abundant inland fish family in Europe. There are currently about 20 species of cyprinids in Finnish fisheries (Yrjölä et al. 2015). Burned cyprinid bones are constantly found at Stone Age sites throughout Finland, indicating that they were an important part of subsistence strategies at the time.

Only a small proportion of the cyprinid skeletal elements have clear species-specific osteomorphological differences. Therefore, the bones can mainly be identified by family. The species can be identified, for example, from the pharyngeal bones behind the gills. A few other bones can also be identified to a species level (see also Radu 2005). However, this can only be done using relatively large fragments. As a result, usually only a few such fragments can be identified by species in burned material.

Still, cyprinid species identification can be important. The geographical distributions of the different cyprinid species differ. Some species, such as roach, live almost all over the country, while others, such as tench, now have a southern distribution (Yrjölä et al. 2015). Species distributions are affected, for example, by water temperature and eutrophication. The warmer climate of the Stone Age is evident in the vegetation pattern (e.g., Donner 1978; 1995; Simola 2003; Seppä et al. 2009b). It may also be reflected in the distribution of fish species, as fish are sensitive to changes in their habitat. In addition to information on their distribution areas, the species identification of cyprinids can provide us with

SITE	PERIOD	ROACH	RUDD	BREAM	BLUE BREAM	IDE	CHUB	TENCH	CRUCIAN CARP
Taivalkoski Tervaniemi	Mesolithic			41					
Kuhmo Vasikkaniemi SW	Mesolithic		9						
Honkajoki Lauhala Hietaranta	Mesolithic	4	6		1		3		
Vantaa Jönsas pohj.	Mesolithic	1							
Askola Siltapellonhaka	Middle Mesolithic			1					
Ii Kuivaniemi Veskankangas	Late Mesolithic			15					
Ranua Mattila	Late Mesolithic - Early Neolithic			1					
Kuhmo Katerma Järvelä	Mesolithic and Neo-lithic			3					
Saarijärvi Summassaari Eteläranta	Mesolithic and Neo-lithic			13					
Äänekoski Kapeenkoski	Mesolithic/Neolithic ?	3							
Saarijärvi Rusavierto	Mesolithic, Neolithic, Early Metal Period	15	24	16		1			
Hyrynsalmi Koppeloniemi	Mesolithic, Neolithic, Early Metal Period	1							
Veteli Kiikkuniemi	Early Neolithic								
Oulu Ylikiiminki Latokangas	Early Neolithic		3						
Oulu Ylikiiminki Vepsänkangas	Early Neolithic	1							
Padasjoki Leirintäalue	Early Neolithic		1						
Rantasalmi Rantakartano	Middle Neolithic					1			
Taipalsaari Vaateranta	Middle Neolithic		1						
Saarijärvi Summassaari Uimaranta	Middle Neolithic		3	3					1
Joroinen Kanava	Middle Neolithic	6	7	14		3	2	13	1
Kangasala Sarsa	Neolithic		1				1		
Kymi Ylänummi Nikkarinmäki	Neolithic		1						
Vantaa Jokiniemi Sandliden	Neolithic	1				1			
Viipuri Häyrynmäki	Neolithic	1							
Hartola Lohentie	Neolithic	1				1			
Rääkkylä Kotilansalo	Neolithic							1	
Virolahti Meskäärtty	Neolithic		2			7		1	
Vantaa Maarinkunnas	Middle and Late Neolithic		2				1		
Outokumpu Sätös	Middle and Late Neolithic	1							
Savonlinna Kerimäki Martinniemi	Middle and Late Neolithic		3	2		1			
Helsinki Malminkartano Kårböle	Middle and Late Neolithic	1	1						
Oulu Hangaskangas E	Late Neolithic			1					
Puumala Kärmelahti	Late Neolithic					1			
Nilsiä Lohilahti	Late Neolithic	3		2		2	4		
Virolahti Kattelus	Late Neolithic	1	1						
Suomussalmi Tormua Särkkä	Late Neolithic	1							
Taivalkoski Uittoniemensalmi	Early Metal Period?		1						

Table 23. Cyprinid species in the Stone Age (NISP). *Roach = Rutilus rutilus, Rudd = Scardinius erythrophthalmus, bream = Abramis brama, blue bream = Ballerus ballerus, ide = Leuciscus idus, chub = Leuciscus cephalus, tench = Tinca tinca and crucian carp = Carassius carassius*

other useful information, as can be seen from the Taivalkoski Tervaniemi spawning bream pit.

9.2.1 Cyprinid species identifications

Individual cyprinid species have not been identified in bone analyses before my studies, and in the past, there was no reference collection that would have made it possible. Some older bone analyses from the 1980s include identifications of bream and ide, but after checking them, I changed the identification to the higher taxon, cyprinids. In the 1980s, the cyprinid fish reference collection at the Finnish Museum of Natural History LUOMUS contained only one incomplete skeleton of a bream and a few single bones of ide, and these earlier identifications were apparently made according to these specimens. Other cyprinid species had no representative skeletons in the collections at all and, consequently, it was not possible to make comparisons between all the different cyprinid species.

For the purpose of this study, I carefully studied cyprinid fish and their bone identification. First, I learned about the species, and then prepared the reference skeletons. During subsequent studies I focused on recognizing the species differences in the bones. I went through all the old osteological analysis reports, collected the numbers of cyprinid bone fragments suitable for species identification, and re-analysed them. Most of these bone fragments turned out to be unsuitable for species identification. However, some of the fragments were large enough and well enough preserved to be useful, and I discovered that when using a good reference collection, cyprinids can also be identified by species even in burned material. I then compiled Table 23, representing all cyprinid bone fragments from Stone Age sites that could be identified to the level of species. Table 23 also includes bones of the cyprinid species I have identified in connection with other bone analyses, including the sites discussed in this dissertation.

Most of these identifications were made from pharyngeal bones, but some other bones, such as the basioccipitale and palatinum, have also been used. In addition to the identifications given in the table, there were numerous cyprinid bone species identifications that could be judged as possible, even if uncertain. Such fragments may have been eroded or were too small, leaving species identification uncertain. Sometimes a fragment may have had two or three alternatives for exact species, but these dubious identifications are not listed in this table. Many of these sites were excavated decades ago (excavations between 1909 – 2014), and therefore accurate dating results are not available for all locations. Therefore, the sites are mainly divided into the Mesolithic and Neolithic periods.

Of three common present-day cyprinid species, roach and bream have been found throughout the Stone Age material, and ide at least from the Neolithic period. Rudd and chub are not as widespread today as the three aforementioned species, but have also been found throughout the Stone Age. Tench and crucian carp have appeared at only a few Neolithic sites.

There is only one identifiable bone fragment of blue bream: a basioccipitale from the Mesolithic site Honkajoki Lauhala Hietaranta. When preparing the reference skeletons, I noticed that blue bream bones were more fragile and fatty than the bones of other cyprinids. This fact certainly contributes to their poorer preservation, on the assumption that fatty bones preserve less well than non-fatty ones.

Many of the current species of cyprinids, such as white bream *(Blicca bjoerkna)* and brackish water vimba bream *(Vimba vimba)*, are not found at all in the Stone Age contexts. However, this does not mean that they did not exist or were not fished. Considering all the taphonomical factors affecting the preservation and recovery of bones, as well as the difficulty in identifying cyprinid species, it is just a coincidence that even these burned bone fragments now identified by species have survived in the archaeological deposits.

9.2.2 Geographical distributions of cyprinid species

As mentioned before, the distribution ranges of the different cyprinid species differ. Information on the exact distribution of fish species is rather fragmentary. The two reference books (Koli 2002; Yrjölä et al. 2015) differ in their accounts of many ranges, and in the more recent book many fish species appear to be more northerly than in the earlies book. A good source for viewing current fish distributions is the web site http://kalahavainnot.luke.fi/kartta of the Natural Resources Institute Finland LUKE, but even this is incomplete and includes only reported species observations.

Because of the differences between the distribution pattern shown in the books and the web source, I asked fisheries Professor Emeritus Hannu Lehtonen about the southern fish distributions. According to Lehtonen, fish distribution areas are nowadays constantly moving northward as the climate becomes warmer. In the Tornionjoki River, for example, several species have been found to have moved further north in a relatively short time. Humans also influence distribution areas by introducing species to new waters, as has happened for instance with pikeperch, tench and crucian carp. In addition to the above reasons, the form of presentation influences the current distri-

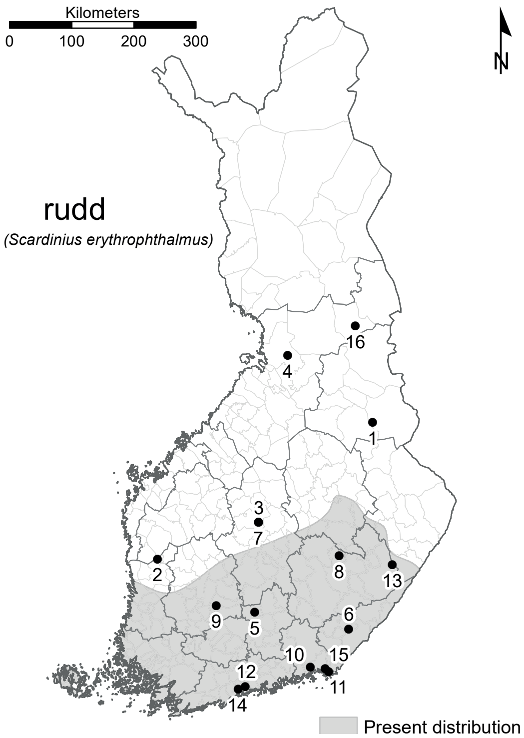


Figure 73. Stone Age rudd finds from Finland. Current distribution: http://kalahavainnot.luke.fi/kartta 1. Kuhmo Vasikkaniemi, 2. Honkajoki Lauhala Hietaranta, 3. Saarijärvi Rusavierto, 4. Oulu Ylikiiminki Latokangas, 5. Padasjoki Leirintäalue, 6. Taipalsaari Vaateranta, 7. Saarijärvi Summassaari Uimaranta, 8. Joroinen Kanava, 9. Kangasala Sarsa, 10. Kymi Ylänummi Nikkarinmäki, 11. Virolahti Meskäärtty, 12. Vantaa Maarinkunnas, 13. Savonlinna Kerimäki Martinniemi, 14. Helsinki Malminkartano Kårböle, 15. Virolahti Kattelus, 16. Taivalkoski Uittoniemensalmi. Materials: National Land Survey of Finland, Administrative borders 2019. Map: Perttu Strandman

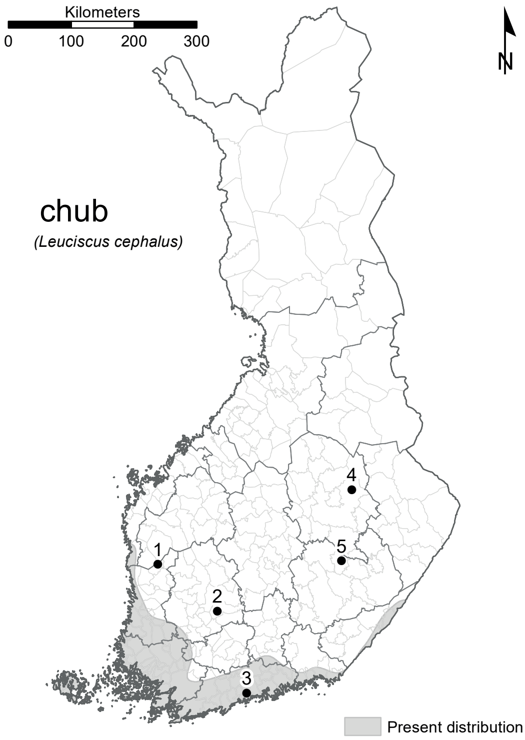


Figure 74. Stone Age chub finds from Finland. Current distribution: http://kalahavainnot.luke.fi/kartta 1. Honkajoki Lauhala Hietaranta, 2. Kangasala Sarsa, 3. Vantaa Maarinkunnas, 4. Kuopio Nilsiä Lohilahti, 5. Joroinen Kanava. National Land Survey of Finland, Administrative borders 2019. Map: Perttu Strandman

bution maps. For instance, the entire geographic area stretching between points of isolated observations can be coloured in as if the whole area has been confirmed, although there will certainly be waters where certain species are not to be found (Lehtonen pers. e-mail 20.11.2019).

Archaeological cyprinid bone fragments identified by species were recovered mainly within the same areas that the respective species can be found in today. Although there are only a small number of such fragments, it can be said that the distribution pattern of most species was the same during the Stone Age as it is today. However, two species are an exception. Rudd and chub live only in the south today, but many Stone Age specimens came to light surprisingly far towards the north (Figures 73 and 74). Although current geographical distribution data are incomplete, there is such a large difference between these finds and the current ranges that it cannot only be explained by incomplete observations. Whether it was a warmer climate or some other biological or geological cause, these two species lived further north during the Stone Age than is suggested by their present-day sightings. Similar results were obtained in the Onega River basin in north-western Russia, where rudd and other warm water fish species were found at Late

Neolithic sites (Tsepkin 1999) even though they are absent there today. The difference between these findings and the archaeological occurrences in Finland is that the Late Neolithic species in the Onega River basin are not found in older layers (Tsepkin 1999), unlike in Finland where they are present already in the Mesolithic period.

9.2.3 Discussion and conclusions

Fish species have different lifestyles. Smaller species, such as roach, live more often in shoals, while some larger species, such as ide, more often live alone. Fish lifestyles can also play a role in fishing. When fishing with a seine, for example, a whole shoal of fish can easily be caught at the same time, as can be seen in the bone refuse found in the hearth bottom at Taivalkoski Tervaniemi. As mentioned before, the fish pit discovered at this is a perfect example of why the identification of cyprinid species matters. All of the identified bones in the pit were of breams, and the fish also fell within same size range. Thus, these fish most probably originated from a single catch of a spawning or eating shoal, a typical catch for seine fishermen.

Perhaps the most interesting result is the difference detected between the distribution of prehistoric rudd and chub compared to the current situation. These two species of fish, at home in warm and eutrophic waters, were found in much more northerly regions than expected. The climate in the Stone Age was warmer than today, and this is most likely the cause of the northern discoveries of these two species. The difference in climate conditions must have been visible, for example, in the shorter duration of the winter period, also resulting in a shorter time when the waters were frozen. When waters stay open longer during the autumn and ice melts earlier in the spring, coastal fishing becomes easier and requires less resources than wintertime ice-fishing. All of these factors increase the profitability of fishing as a subsistence strategy. When fish are easily available from nearby one´s home, this reduces the need for less reliable and sometimes dangerous hunting trips. Natural conditions can greatly affect people's daily lives, which is important to remember when reflecting on Stone Age life.

10 Discussion

10.1 The influence of taphonomy and excavation methods on the results

Archaeological fish bone material in Finland differs from the material usually recovered, since only the burned bones have been preserved. After thousands of years underground, erosion will also inevitably destroy some bones, and only a small part of them will survive to this day. Burning significantly increases the rate of bone destruction, and only a very small proportion of the original bones in Finland have thus been preserved.

Finding bones is often a coincidence. Excavations are usually located in confined areas, and although burned fish bones are often found in the cultural layers, actual waste pits may have been located a little further away from the dwelling and, as a result, may not be found. It should also be remembered that dwellings were located along the shoreline, and therefore the waste, such as bones, may have been thrown into the water, especially if the shape of the terrain has generally directed the flow of water away from the shoreline towards an open lake or the sea.

My burning experiment shows that the fish bones found in Stone Age contexts are very similar to the bones that remain after burning. Thick joints and stronger bones are not as badly affected as other thinner and brittle bones when burned. Fragments of some strong bones, such as pike jaws and cyprinidae vertebrae, are actually abundant in many sites. Likewise, most fragile bones, such as thin and flat fish head bones, are missing from most assemblages.

Bone loss is greatest during the burning process, when many bones become unidentifiable or are even completely destroyed. After being buried in a deposit, some of the more fragile identifiable bones that could have survived the burning process will also eventually disintegrate. These fragmented small bones are mixed among the identifiable bones as formless, unidentifiable fragments. Only a small proportion of the burned fish bone finds, usually only 5%, can be identified, due to the natural taphonomical process resulting from burning and subsequent burial. The remaining bones correspond to the species that were likely fished, except for small fish such as herring and vendace whose bones are likely to have been completely burned and destroyed. Based on the number of bone fragments preserved, one species cannot be asserted to have been more important than the other, as the bones' taphonomical stability varies individually between species.

It is noteworthy that in the bone burning experiment the vertebrae of all tested fish species remained very identifiable and largely intact after two burnings. This means that among the burned bones from the Stone Age the vertebrae of all the species fished for should be found. It does not seem likely that all of the vertebrae from a species could have been destroyed, except for the smallest species that leave no preserved bones in general. This is something to be aware of, especially when we track salmonids and their role in fishing during the Stone Age.

Excavation techniques, and especially screening, also affect the final results, as is shown in my screening test. The 4 mm mesh most often used to screen the culture layers is too wide for burned fish bones. It leads to the over-representation of pike bones and obliterates the existence of smaller fish such as perch and small cyprinids. Findings made with a too-large mesh size distort the picture of fishing for the entire Stone Age. Based on more carefully screened findings from bone pits, small fish have actually been abundantly fished during the Stone Age.

Burning and other taphonomical processes, as well as the excavation techniques employed, must always be considered when interpreting the information provided by fish bones. Much of the bone remnants of fish that were once caught have been destroyed at some point after being thrown into the fire, and some are often left unrecovered. In addition, the determination of the presence of individual species is affected by differences in bone preservation and the number of bones eligible for species identification. The latter is particularly evident in identifying the cyprinid species. While bones screened through a large mesh tend to yield many of pike head bones and a few cyprinid vertebrae, this does not mean that the pike was the most important prey fish in the area. Rather, it means that pike is a fish whose bones are most likely to be found. Other species were likely also present, but some bones suffer more from burning and erosion, or can only be recovered through the use of a finer mesh.

10.2 The fish distribution patterns and climatic conditions reflected by the bone finds

When I started this study years ago, I had high expectations of being able to clarify the distribution areas of the fish species in the Stone Age and the effects of the warmer climate of that time on the distributions on the basis of the fish bone finds. Since then, signs of current climate change have begun to show clearly in Finland, especially in the milder, rainier, and more snowless winters of the south.

The identification of current fish ranges differ depending on the source, as discussed in chapter *9.2 Case study 2: Cyprinids in the Stone Age*. In addition to this, many current fish observations are incomplete. According to fisheries Professor Emeritus Hannu Lehtonen, fish distribution areas are nowadays constantly moving northward as the climate warms, verified for example in the Tornionjoki River area north of the Gulf of Bothnia, at the border between Finland and Sweden (Lehtonen pers. e-mail 20.11.2019).

As the results of my bone analyses show, the same fish species that are common in our waters today have been fished in Finland during both the Mesolithic and the Neolithic ages. Minor local differences in distributions have certainly been present throughout prehistory. However, if changes in the current climate are to be seen in only a couple of decades, it is absolutely impossible to show these differences at a time scale of hundreds and thousands of years, especially based on burned bone material, that has suffered from large-scale bone loss due to taphonomy and excavation techniques. Therefore, burned fish bones are not suitable for the precise delineation of Stone Age fish distribution areas.

However, a few exceptions to the effects of warmer climates can be seen in the Stone Age fish bone finds. The most exciting are some of the bone fragments of the long extinct wels from Joroinen and Kerimäki, a species that disappeared from Finland a long time ago (see *5.3 Rare fish species in Archaeological bone assemblages from Finland*). According to the small numbers of wels bones found, it was not a commonly fished species during the Stone Age, but it did exist in Finland at least during the Neolithic period. Wels bones are large and appear to be relatively resistant to damage, so more of them would probably have survived burning if there had been more.

Clear evidence of the effect of warmer climates is evident in the Stone Age finds of the cyprinids chub and rudd. Many bones of these two species have been found well north of their current ranges (see *9.2.2 Distributions of cyprinid species*). Therefore, the difference in climate conditions must have been visible, for example, in the shorter duration of winters (see also Ruosteenoja et al. 2020). As a result, the time when the waters were frozen was likely shorter; and, as waters remained open for a longer time during the autumn and ice melted earlier in the spring, coastal fishing became easier and required less resources than wintertime ice-fishing. All of these factors increase the profitability of fishing as a subsistence strategy. When fish are easily available from nearby one´s dwelling, this reduces the need for less reliable and safe hunting trips. Natural conditions often directly affect people's daily lives, which is important to consider when reflecting on Stone Age life.

10.3 Stone Age fishing methods in Finland and the role of fishing in the Stone Age economy

In this chapter, I discuss Stone Age fishing methods and the importance of fishing in the Stone Age economy. I have divided this discussion into subchapters, starting with fishing methods. The inevitable reflection on missing salmon needs its own discussion, since its absence may seem confusing given that salmon is an important part of our modern diet. I also address two issues raised in the bone analyses and international research: the role of bone pits and the drying of fish. Finally, the last discussion is of the importance of fishing in the Stone Age economy.

10.3.1 Fishing methods in the Stone Age based on fish bone finds

The fish bones found in Finnish Stone Age sites are of species that would have been accessible from nearby banks and shorelines. These species are mainly freshwater fish: pike, perch, pikeperch, cyprinids, burbot, and whitefish. This is evident in all of the bone materials from both Mesolithic and Neolithic sites.

Archaeological artefacts found in Finland (see *5.1 Archaeological evidence of fishing*) show that nets, hooks and lines, gorges, traps, and weirs were well known during the Stone Age. All of these can be used for shoreline fishing.

Pike may also be caught by using a club, spear, or leister. Traps, weirs, and nets, as well as smaller hooks made of organic materials, are suitable gear for catching perch, cyprinids, and whitefish.

Seine fishing, on the other hand, is the most effective method to catch fish shoals near the shore. Seine nets have not been found in Stone Age contexts in Finland (if the Antrea net is not classified as a seine, see *5.1.1 The Antrea net and its knotting*), most probably due to problems of preservation. Nevertheless, seine fishing was certainly a well-known method as early as the Mesolithic, as evidenced by the bream bones from Taivalkoski Tervaniemi and Ii Kuivaniemi Veskankangas. It is also most likely that landing nets and loops made from organic materials have been known from an early age.

It has been suggested that the discovery of ice picks from the Stone Age indicate the practice winter fishing (see *5.1.5 Other fishing gear*). This assumption of winter fishing is confirmed by the finds of burbot bone derived from adult, sexually mature fish (see *9.1 Case study 1: Burbot (Lota lota) bones and winter fishing*). Ice picks can be used to make holes in the ice, under which suitable fishing device can be installed through the holes. There is archaeological evidence of double-pointed gorges, so there is no reason to assume that wooden triple-pointed gorges, which have been widely used as a burbot hooks through history, were not already in use during the Stone Age. In winter, ice fishing with hooks and lines and net fishing under the ice can easily catch perch and cyprinids, for example, which are both abundant in Stone Age bone finds.

In conclusion, Stone Age fish bone finds support the theory postulating the use of historically known simple fishing gear, as described in *4.2 Historical knowledge about ancient fishing methods in Finland*, as early as the Stone Age. These devices have been in use since the Paleolithic period in Europe and North Asia (see *4 Ethnographic background*), and many of them have remained similar for millennia, which speaks to their efficiency in obtaining everyday food.

10.3.2 The salmon question

Stone Age sites in the area of present-day Finland were located on shores and river banks. Many were on the shores of inland lakes, but some were located on the shores of the ancient Littorina Sea. The rivers of the Littorina Sea, as well as the rivers in northern Lapland flowing into the Arctic Ocean through northern Norway, were potential spawning rivers for salmon. Salmon runs have been an important source of subsistence in many cultures among northern foragers around the world (see *4 Ethnographic background*).

The question of the significance of possible salmon runs in the area of present-day Finland during the Stone Age has recently been discussed (Koivisto & Nurminen 2015; Koivisto 2017). In this thesis it became evident, however, that only a hint of salmon bones are found in coastal areas. Salmonid bones are fatty, poorly ossified and fragile and therefore disintegrate rapidly especially when burned. Still, salmonid vertebrae preserve better than the head bones (Lubinski 1996), as is well-reflected in the abundance of whitefish vertebrae in Finnish archaeological assemblages. This is also evident from my burning experiment (see *7.1.2 Burning experiments*), where well over two-thirds of the trout and whitefish vertebrae survived after two burnings. The recent well-preserved finds of the first Stone Age trout bones at the Savukoski Sokli site in eastern Lapland (see *5.3 Rare fish species in archaeological bone assemblages from Finland*) are also of great interest, especially as they include not only vertebrae but also fragile head bones such as the dentale, articulare, quadratum, and praeoperculare (Nurminen 2020). Based on these results, the effects of burning cannot be the sole reason why there are so few salmon and trout bones in the Stone Age material.

The fish bones found at the Simo Tainiaro site (see *8.2.4 Simo Tainiaro*) show that even inaccurate excavation methods, that is either screening for fish bones with a large mesh size or not screening at all, still produce fish vertebrae finds that most people working in the field would recognize as fish. Most of the vertebrae at the Tainiaro site belong to salmonids, both whitefish and others, with the presence of pike, perch, cyprinids, and burbot confirmed. This indicates that burned salmonid vertebrae preserve equally well as the vertebrae of other species. Overall the general lack of salmonid bones in Finnish archaeofaunal assemblages is probably due to factors other than the commonly suggested poor preservation and excavation techniques.

Salmon, as well as trout and other salmonids, were likely to be caught already in the Stone Age if they were accessible. The lack of salmonid finds other than whitefish is most likely due to a combination of environmental conditions, the lifestyles of the fish, and the fishing methods employed. It is a fact that salmonid habitats are not quite in coastal waters. If fishing was, as the bone finds and likely use of suitably simple fishing methods indicate, a small-scale everyday source of food, it was likely practiced from the shoreline with the least possible effort. There may simply not have been a general need to go after a big catch such as a salmon run.

10.3.3 The role of fish bone pits

In Finland, burned fish bones are usually found in and near the hearths of prehistoric dwelling sites. The bones are burned when they are first cooked and then thrown into the fire after eating. Bones can also be found in waste pits or in other large concentrations where they have been specifically collected after the cooking and eating processes. Fish bone pits are rarely found compared to the number of excavated Stone Age sites. In addition to bone preservation problems, one reason is certainly pure coincidence. Excavations are generally performed within a limited area, and waste pits could easily have been located slightly outside the excavation area if the waste was originally disposed a little farther from the actual dwelling or eating site.

The function of fish bone pits deserves a closer look. In addition to bone waste, fresh fish may also have been collected in pits for preservation through fermentation. According to ethnographic research, for instance the Kamchadals in the Kamchatka Peninsula in north-eastern Russia fermented salmon in pits in the ground covered with stone and earth (Jochelson unpublished). Freshwater fish fermentation is suggested to have been known in a nearby area, southern Sweden, as early as the Early Mesolithic period (Boethius 2016; 2018).

During historical times there was lack of salt in Finland and freshwater fish were fermented in pits under heavy weights and then used as food (Manninen 1929; 1932; Naskali 1993). This method of preservation was used at least in inland regions: in eastern Finland and the Province of Häme, as well as among the Sámi in Lapland (Manninen 1929; 1932). In addition to freshwater fish (Itkonen 1948), the Sámi most likely also fermented salmon in the north (Vilkuna 1974). This method of preserving fish is not attractive today, but people were more used to the taste of fermented fish in the old times. Stockfish soaked in a lye solution (*lipeäkala* in Finnish) has long been a traditional Finnish Christmas dish. In my youth my parents always served it at home, and I still remember that annoying smell, but its popularity has diminished tremendously over the past few decades and salmon has replaced it at Christmas tables. In Sweden, *surströmming* (sour herring) is still a special delicacy even today.

As mentioned before, a possible prehistoric fish fermentation pit has been excavated in southern Sweden. At the Early Mesolithic site of Norje Sunnansund, a total of 13,302 unburned fragments of freshwater fish, more than half of them cyprinids, were discovered in a gutter-shaped pit together with only a handful on mammal bone fragments. The bones also included collapsed pike vertebrae (Boethius 2016; 2018). Boethius argues that the collapsed vertebrae indicate that they were subjected to acid (Boethius 2016; 2018). According to Boethius (2016; 2018), this could happen during a fermentation process. However, it can also happen to bones that have passed through the digestive tract, and have thus been exposed to gastric acids (Butler & Schroeder 1998). I have also come across collapsed vertebrae from several fish species relatively often in burned fish bone assemblages. Vertebrae have holes in them, and I suggest that the collapse of these bones is most likely due to erosion and the fact that they have been compressed underground for millennia, especially if the burning was incomplete. In any case, although the species of fish found in the Norje Sunnansund feature are similar to those that were consumed in Finland during the Stone Age, the key difference between this site and the Finnish fish bone pits is that the bones of the suggested fermentation pit are unburned. The construction is, therefore, completely different from what has been found in Finland, where only pits with burned fish bones have been discovered. Bones were burned during meal preparation or afterwards, when thrown into the fire. Therefore, pits containing burned bones could not have been functioning as fermentation pits.

The use of fermentation to preserve fish may also have occurred in Finland during the Stone Age, but direct evidence of this may be difficult to find. If fermentation was already used by Stone Age foragers, it must have happened in separate pits. It is also likely that the bones of fermented fish were also thrown into the fire after eating, or that former fermentation pits were later used as waste pits. To study such an issue would require soil chemistry tests of the pits.

10.3.4 Drying of fish

Preservation of fish by drying has been common in the northern regions, as is shown by many examples in the ethnographic literature (e.g., Manninen 1929; 1932; Sturtevant 1981; Virrankoski 1994; Fagan 1995; Anderson et al. 1998; Glavtskaya 2006b). The drying of fish has also been important in Finland in historical times (Manninen 1929; 1932; Naskali 1993), and dried fish has been widely used as a substitute for bread (Manninen 1929; 1932). In inland waters the most important types of fish used for drying have been pike, bream, perch, roach, and also a salmonid, vendace. Of these, pike has been the most important. Fatty fish, such as salmon, are not described as well-suited for this purpose (Savikko et al. 2012). However, it was common for the Sámi in Lapland to dry salmonids; trout, arctic charr, whitefish, and vendace, together with pike and perch (Itkonen 1948). Dried pike and whitefish have also been commonly used as trade goods in Lapland (Itkonen 1948). Fish was often dried in the open air (Manninen 1929; 1932; Itkonen 1948; Naskali 1993), and *kapahauki* (dried pike) is still a familiar word to many Finns.

A specifically interesting question raised by my burning experiment (see *7.1.2 Burning experiments*) concerns pike. Pike was well preserved after burning, including both the head bones and vertebrae. In Finnish Stone Age fish remains, however, pike vertebrae are quite rare, even though pike head bones are found in large numbers in sites throughout the country. What happened to the pike vertebrae?

The pike has proportionally a lot of meat, and the bones of the pike body are small and thin in relation to the body size of the fish, compared to, for example, percids or cyprinids. On the other hand, the pike head is full of thick bones. Pike meat has relatively low fat content, and therefore it is ideal for drying. In this study, it has been shown that burned pike assemblages throughout the Stone Age are rich in head bones but contain noticeably few vertebrae, although pike as a long fish have many of them.

The relative abundance of pike head bones has been interpreted variously over the years. Suspected reasons included the pike having been the most important (and sometimes the only) fish catch, the fact that the pike vertebrae may have been destroyed by burning due to their more fragile structure, or the lack of vertebrae being identified in past excavations. Although the latter demonstrably reduces the number of species identified, all of these theories can be refuted on the basis of my bone analyses including vertebrae, as well as buy my burning experiment. The experiment showed that pike was well preserved even after two burnings, including both the head bones and vertebrae. Because of the considerable lack of vertebrae in many Stone Age pike remains compared to other fish, it appears that pikes were sometimes treated differently than other fish, at least at the studied sites. Pike carcasses could have been dried and stored, and only the heads cut off and thrown into the fire. Perhaps the dried body parts were eaten later away from the fireplace, or pike vertebrae were left at the bottom of a single campfire off-site, where they would never be found.

When something is found that is different from other similar material, such as the missing pike vertebrae, trade is often suggested as an explanation. In this case, the possibility of trade is unlikely. Finland is, and already was in the Stone Age, full of lakes that were plentiful with pikes easy for anyone to catch. However, sometimes food had to be stored for bad days or possible hunting trips. Most fish species identified at Stone Age sites are ideally suited for drying, and in particular the scarcity of pike vertebrae in the material available for study strongly suggests the preservation of fish by this method. Hypothetically, the absence of pike vertebrae could also be due to some rituals unknown to modern people. Nevertheless, it can be suggested that dried fish was a common everyday food during the Stone Age, especially if there were no practical alternatives.

10.3.5 The role of fishing in the Stone Age economy

Fish bone finds from Finland are, on the whole, uniform throughout the Stone Age. All variation can be explained by the location of individual sites, environmental aspects, and excavation methods. Fishing has been widely practiced since the early Mesolithic period, and the species caught have not changed over the millennia. Therefore, it is plausible that fishing methods have also remained the same from the Stone Age on, using methods inherited from the Palaeolithic period and already known when people first came to the territory of present-day Finland after the retreat of the ice.

The sites were located on shorelines that are, and were already in the Stone Age, plentiful in Finland and make fishing easy. It was possible to keep traps and nets in the water next to the shore on a daily basis, and larger fish could be caught using hooks or spears. Spawning or foraging fish shoals were easy to encircle with a seine. These fish catches were easily accessible nearby the settlements of Stone Age; quite simply, fishing was possible with little effort.

Although the annual mean temperature was higher than today during the Stone Age in Finland, and the Littorina Sea might not have been frozen to the extent of current seas because of the warmer climate and the higher salinity of the water, inland waters were most likely frozen to the same extent as they are today, albeit probably for a shorter period of time. Fishing methods and gear have been similar among the northern forager cultures from prehistoric times, and ice fishing has been known since the Palaeolithic period (*see 4.2.6 The significance of ice fishing*). Bones of adult, sexually mature burbot, which are a typical winter catch, have been found at Finnish Stone Age sites. In addition, smaller fish can be caught under the ice using hooks and lines, nets, and traps. It is therefore reasonable to assume that the prehistoric people in Finland were practicing ice fishing in the same way as other groups living under similar circumstances. Ice fishing allows fishing even during the winter, therefore fishing was possible all year round. However, there may have been some seasonality between species, especially at the time of spawning, although various species may have complemented each other in the summer calendar.

If fishing took place on the same site continuously, it is worth considering whether the local fisheries were able to withstand it. Did the supply of fish run out at some point? The settlements of the Stone Age were small, which means that mass harvesting was not likely to have been practiced anywhere. It is not reflected in fish bone assemblages either, except for individual spawning flocks, such as the breams at the Taivalkoski Tervaniemi site. As can be seen in the site palaeomaps (Figures 27, 29, 31, 35, 47, 51, 53, 57, 61, and 62 in the chapter *8 Fish bone analyses from Stone Age sites*), the Stone Age sites were located on the shores of large bodies of water. The large lakes and the Littorina Sea most likely contained enough fish for a small community without fear of running out of food, even if fishing was practiced every day of the year. One may presume that during the Stone Age fishing was mostly an opportunistic, low-level daily activity, and that all types of fish were considered equally fit for consumption, unlike in modern times when most people are very selective about their food.

It is obvious that fishing was an important source of sustenance among the foragers living in the area of present-day Finland throughout the Stone Age. The general consistency of fish bone finds over thousands of years indicates the essential and uncomplicated integration of fishing into everyday life. Material culture, customs, and beliefs can change, but the foraging practices sustaining everyday life often remain the same.

Unfortunately, due to the acidic nature of Finland´s soil, there has not been an opportunity for isotopic studies of human bones that would provide another line of evidence for the importance of fishing. Residue analyses of pottery, which is still a new line of research in Finland, show residues from both terrestrial and aquatic animals (e.g., Papakosta & Pesonen 2019), as do bone analyses. These individual analyses are a glimpse into Stone Age cooking and storage practices; however, they do not show direct evidence of other methods of food preparation and do not allow conclusions to be drawn from the Mesolithic, when pottery was not yet in use.

Plants hibernate during the cold winters and are therefore mostly unavailable, even if berries and nuts may have been preserved for consumption in the winter and spring. Hunting often requires longer and more uncertain trips. In contrast, fishing was an easy means of procuring sustenance that could be pursued in people´s own backyards and was available all year round, as the studied bone assemblages have shown. Therefore, I would argue that fishing was the most reliable source of daily food in Finland during the Stone Age.

10.4 Past, present, and future – a Finnish perspective on eating fish

Freshwater fish caught from the near shore has been an important source of food for Finns throughout documented history. As this study shows, the widespread consumption of freshwater fish is a long tradition going back at least to the early Stone Age in the area of present-day Finland. However, sometimes during the 20th century, along with the effects of growing urbanization, the natural food of our own environment has been forgotten. The intensive livestock farming of beef, pork, and poultry - and farmed salmon imported from Norway - has become the new normal.

Recently, there has been a slow awakening to the health problems caused by eating large amounts of red meat, as well as its effects on global climate warming, which is also affected by livestock farming. Abundant grain is grown for livestock, even though food could be grown for humans in the same fields. At the same time in Finland, smaller fish, such as herring, are caught in abundance as feed for farmed animals.

I was recently involved as a "guinea pig" in a clinical study on the health effects of plant and animal proteins. According to the results, increasing the proportion of plant proteins in a diet is beneficial to cardiovascular and intestinal health (Päivärinta et al. 2020). As for the fish, the Finnish Institute for Health and Welfare recommends eating it for, among other things, improving cardiovascular health. Fortunately, despite the general spread of environmental toxins, Finnish lakes and their fish are still considered fairly unpolluted.

Recently, various processed fish products made from cyprinid fish have started to appear in food markets. As cyprinids are full of bones, including ossified tendons in the trunk, these products offer an opportunity for many individuals who would normally avoid consuming fish laden with bones to rediscover Finnish traditional food. The next step would be to learn to appreciate the basic foods of our ancestors as it was. Thus, striving for a healthier life can be linked with tradition and identity, adding an emotional motivation to improving the country´s health record.

11 Conclusions

Based on the results described and discussed in this study, several topics can now be more thoroughly and accurately discussed. It is argued that:

1 Fishing was the most reliable source of daily food in the region of modern-day Finland during the Stone Age. Fishing was a mostly opportunistic, low-level daily activity and all fish were considered equally fit for consumption.

2 Taxonomic composition
2.1 Fish bone finds from Finland are generally uniform throughout the Stone Age. The fish bones found are of species that were easily accessible from the nearby river banks and shorelines. These species are mainly freshwater fish, the same species that are common in our waters today: pike, perch, pikeperch, cyprinids, burbot, and whitefish. This is evident in all bone materials from both Mesolithic and Neolithic sites.

2.2 All variations in identified fish species can be explained by the location of the sites, environmental aspects, and excavation methods.

2.3 The lack of salmonids other than whitefish is most likely due to a combination of the effects of environmental conditions, the lifestyles of the fish, and the fishing methods used. Apparently, salmon runs were not taken advantage of on a large scale.

3 Taphonomic effects
3.1 Burning is a major taphonomical cause of bone loss. At the same time, it contributes to the preservation of compact skeletal parts. The fish bones found in Stone Age contexts follow the same pattern as bones that would be expected to survive after burning. Thick joints and stronger bones are not as badly affected by burning as thinner and brittle bones.

3.2 The vertebrae of all fish species that were used in the burning experiment remained clearly identifiable and largely intact. Therefore, we can expect that the vertebrae of the species caught should be found among the burned bones assemblages of Stone Age contexts.

3.3 Based solely on the number of bone fragments preserved, no single species can be asserted to have been more important than any other, as the bones' taphonomical stability varies between individual species.

3.4 Excavation techniques, and especially screening, directly affect the final results of fish bone analyses. The data derived from excavations that used overly large (4 mm+) mesh-size for screening distort our understanding of fishing. Most of the identifiable fish bones could be retrieved with a 2 mm screen, which is the recommended mesh size for burned fish bone concentrations.

4 Long term environmental trends
4.1 Burned fish bones are not suitable for the precise delineation of Stone Age fish distribution areas. These areas may change over a couple of decades due to changes in the environment. In addition to the long time scale of the Stone Age, the effects of large-scale bone loss due to taphonomy and excavation techniques make such delineations impossible.

4.2 The effects of the warmer climate of the Stone Age can be seen in some of the Stone Age fish bone finds. Many bones of the cyprinid species chub and rudd have been found well north of their current ranges. Some bone fragments of the long extinct wels have also been found.

5 Fishing techniques
5.1 The Stone Age fish bone finds support the theory postulating the use of historically known simple fishing gear such as clubs, spears, leisters, loops, hooks and lines, gorges, traps, weirs, sei-

nes, and nets. All of these tools can be used for shoreline fishing. Based on the fish bone data, the fishing methods utilized have remained the same throughout the Stone Age.

5.2 The Antrea net knot is incorrectly identified in previous sources. I suggest that, from now on, the knot should be called a weaver´s knot, *kutojansolmu* in Finnish (which is equivalent to a sheet bend, *jalussolmu* in Finnish). This would serve both clarity and linguistic consistency.

5.3 In principle, it is possible to catch most of the fish species identified in the Stone Age assemblages all year round from the shoreline. Fishing in the spring, summer, and autumn did not require much effort, but the winter ice poses its own challenge. The practice of winter fishing through holes in the ice is confirmed by the burbot bone finds derived from adult, sexually mature individuals. In addition to the burbot, other species such as pike, perch and cyprinids can also be caught under the ice. Therefore, fishing was probably a year-round activity with some seasonal variations. This may indicate more year-round occupation of Stone Age sites than has been considered, rather than use as temporary camps.

5.4 Direct evidence of preservation methods has not been found. The historical and ethnographic literature contains many examples of preservation by both fermentation and drying. Fermentation is usually performed in a pit, but the pits containing burned bones could not have functioned as fermentation pits, and the study of this issue would require the broad use of soil chemistry tests. Instead, it can be suggested that dried fish was a common everyday food during the Stone Age, and the common use of drying is a possible explanation for the scarcity of pike vertebrae in the absence of alternative explanations.

For future fish bone studies to prosper, it would be essential to have access to more extensive bone assemblages. This would in turn require more extensive excavations and proper surveys of entire Stone Age sites. In such comprehensive studies there would probably be more potential to identify waste pits and other bone concentrations that could hold a wealth of fish bones – and thus produce new information. Admittedly, all of this is a major economic issue that is not supported by the forces of a market-driven economy. In addition to access to more extensive bone assemblages, the creation of a more comprehensive reference collection would also be useful.

As is shown in this study, even small finds can be of great significance. Numerous small excavations and surveys of Stone Age sites have already been carried out, and a rather clear large-scale picture could be outlined from them in this study. It is unlikely, however, that further small studies would contribute significant additional information to these results. Yet, bone identification from small assemblages is still locally important to individual site studies, as it can provide valuable information on the prehistoric life of specific areas.

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Appendix

Taphonomy of burned fish bones – burning experiments in the open fire

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Burned fish bones are frequently discovered in excavations of Stone Age settlements in Finland. All the surviving fish bone finds from the Stone Age are burned and very fragmented. The aim of this experimental bone-burning study was to find out what burning actually does to the bones. How much of the original bones is destroyed in the fire before the remains are preserved in the ground and how does this affect the conclusions we can make about the fish bone finds?

Keywords: Archaeology, Stone Age, Fishing, Finland, Fish, Refuse fauna, Burned bones, Bone

Introduction

Burned fish bones are frequently discovered in excavations of Stone Age settlements in Finland. An abundance of fish bones among the faunal remains and the location of settlements mainly along the shoreline indicate the great importance of fishing in Stone Age economy.

Fishing gear finds have been mentioned in other archaeological studies (e.g., Edgren 1984, 19–20, 68–70; Minkkinen 1999; Naskali 2004; Schulz 1997, 1998, 158–160). Fish bone finds have not been studied thoroughly since my earlier work on the subject (Nurminen 2006, forthcoming). Actual fishing gear, such as fishing hooks and net weights, are rare among Stone Age materials. Most of the objects used for fishing are presumed to have been made of organic materials, and therefore they have not been preserved. Organic matter decomposes quickly in Finland's acidic soils.

Fish bones are found in and near hearths within prehistoric settlements. The bones have been burned in connection with cooking or meal preparation, and the remaining bones have been thrown into the fire. As bone burns, a hard top layer is formed which enhances preservation. Bones are also found in garbage pits or other large concentrations in which they were collected specifically as waste.

There is plenty of historical and ethnological literature on fishing. These sources, together with Stone Age fish bone finds, can help to draw conclusions about Stone Age fishing methods. Was fishing only practised for personal subsistence or was it extensively organised for large numbers of people? What species were caught and what kinds of equipment were suitable for catching these species? Did fishing take place during certain times of the year or was it practised year-round?

Based on this information, were settlements seasonal or year-round? The relative representation of fish bones is crucial in terms of interpretation.

In Finland, all surviving fish bone finds from Stone Age contexts are burned and highly fragmented and mainly consisted of joint surfaces and other thick parts of the skeleton. Whole vertebrae have also been preserved. The bones of various fish species are preserved in different ways. In drawing conclusions about burned fish bone finds, it is important to know what burning actually does to the bones. How much of the original bones is destroyed in the fire before the remains are preserved in the ground? I have studied the destruction of fish bones by grilling fish in the open fire and then throwing the bones into the fire as was done in the Stone Age. The results of my studies are presented in this paper.

Materials and methods

Stone Age fish finds in sites throughout Finland consist mainly of freshwater fish (Nurminen 2006, forthcoming). The most common species is pike (*Esox lucius*). The pike bones found are mostly parts of the hard head bones, such as dentale and palatinum. These bones are usually preserved even when the rest of the bone material is almost completely destroyed. Pike vertebrae are rarely found but usually occur in contexts where there are plenty of other fish bone remains.

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Perch (*Perca fluviatilis*) and cyprinids (Cyprinidae) such as roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), bream (*Abramis brama*), ide (*Leuciscus idus*) and chub (*Leuciscus cephalus*) are common in Finnish Stone Age fish finds. In both perch and cyprinids, all skeletal elements are well represented.

The only salmonid fish commonly found is whitefish (*Coregonus lavaretus*). Almost all the whitefish bones are vertebrae, which seem to preserve quite well. I have found only a couple of salmon (*Salmo salar*) and grayling (*Thymallus thymallus*) vertebrae in Stone Age materials in Finland, but never any trout (*Salmo trutta*) vertebrae.

Burbot (*Lota lota*) is a rare species yet still has been encountered throughout Finland. Burbot finds seem to be related to winter fishing during its spawning time in January and February (Nurminen forthcoming).

For the burning experiments presented in this paper, I chose the freshwater fish species commonly found at Finnish Stone Age sites. The fish were caught in a lake in Keuruu, Central Finland. My sons went angling at the lakeshore and got some perches and cyprinids and a small pike. A bigger pike was caught deeper in the lake with a rod and reel from a boat. The rest of the bigger fishes, such as whitefish, bream, big perch and, for the sake of comparison, trout, I bought fresh from the market. All the fish were of Finnish origin.

For this experimental burning study I had the following fish:

– 2 pikes (*E. lucius*), 47 and 22 cm long.
– 6 perches (*P. fluviatilis*), 30 cm (330 g), 17, 13, 11, 11 and 10 cm.
– 10 roaches (*R. rutilus*), 19, 18, 18, 16, 15, 14, 12, 12, 11 and 10 cm
– 3 ides (*L. idus*), 18, 13 and 12 cm
– 1 bream (*A. brama*), 37 cm (590 g)
– 1 whitefish (*C. lavaretus*), 43 cm (c. 1 kg)
– 1 trout (*S. trutta*), 41 cm (c. 800 g)

For the actual burning, I first gutted the fish and then grilled them in the open fire with heads, scales and fins still included. Then my family and I ate the fish flesh and threw the skin and bones into the fire. I let the fire go out slowly by itself.

When the fire was out, I sieved the bones from the charcoal with water and a 2 mm sieve. Small sieve sizes are preferable when sieving fish bones (Zohar and Belmaker 2005). I have tested the 4, 2 and 1 mm sieve sizes with burned bones previously (Nurminen 2015, forthcoming) and concluded that the 2 mm sieve is the best for sieving burned fish bones. In my test, only small unidentifiable fragments and the middle parts of costa, lepidotrichia and pterygiophora passed through the 2 mm sieve. The only identifiable parts lost in this way were the costae of perch. This was not a significant loss because other perch bones were still preserved. I counted and identified the bones. Then I burned all these identifiable bones a second time and sieved, counted and identified them again.

Results

First burning

After the first burning, I had a total of 38.18 g of burned bones, of which 19.2 g (50%) were identifiable. No scales or otoliths were preserved in the burning. The smallest otoliths may have passed through the sieve, but I also checked the sieved materials and found no otoliths there either. Table 1 lists the bone remains following the first burning.

Pike (*E. lucius*)

Pike bones preserved well, especially those of the bigger individuals. After the first burning, there were a large number of head bones left as well as many vertebrae, ribs and fins.

Perch (*P. fluviatilis*)

Perch bones seemed to be more fragile than I had thought before starting this experiment. The number of fragments after the first burning was almost the same as that for pike. In the beginning, I had six perches but only two pikes, although the perches were mostly quite small. The minimum identifiable number of individual perch after the first burning was only three. The number was counted from the praeoperculare bone. The results of this experiment reflect the representation of Finnish Stone Age fish bone materials (Nurminen forthcoming). In the Stone Age refuse fauna, perch bones of many sizes are preserved, but a large number of the bones come

Table 1 Bone finds after first burning

Species	Weight (g)	Fragments	Vertebrae	Vertebrae %	Individuals
Pike	7.51	182	112	62	2 (of total 2)
Perch	2.30	183	120	66	3 (of total 6)
Roach and ide	1.69	345	228	66	12 (of total 13)
Bream	3.16	93	44	47	1 (of total 1)
Whitefish	2.33	83	65	78	1 (of total 1)
Trout	2.21	72	63	88	1 (of total 1)

Table 2 Bone finds after second burning

Species	Weight (g)	Fragments	Vertebrae	Vertebrae %	Individuals
Pike	5.78	170	109	64	2 (of total 2)
Perch	1.87	156	117	75	2 (of total 6)
Roach and ide	1.03	277	204	66	8 (of total 13)
Bream	2.50	92	45	49	1 (of total 1)
Whitefish	1.52	74	69	93	1 (of total 1)
Trout	1.55	64	61	95	1 (of total 1)

from small individuals (Nurminen forthcoming). The results of this burning experiment might indicate that perch was more significant in Stone Age economy than the faunal remains may seem to suggest.

Cyprinids (Cyprinidae), roach (*R. rutilus*), ide (*L. idus*) and bream (*A. brama*)

Cyprinids are common among Finnish fish bone remains. My specimens were mostly small, and a lot of the head bones were destroyed in this experiment. Bream preserved well, but the specimen was much bigger than those of the roaches and ides used in the experiment. In spite of this, almost all of the cyprinid individuals were still found after the first burning; only one roach had been completely destroyed. The minimum number of individual roaches was counted from the pharyngeal bone and that of ides from the basioccipitale.

Salmonids (Salmonidae), whitefish (*C. lavaretus*) and trout (*S. trutta*)

Salmonid fish are commonly known to be fatty and their bones contain fat. This can be demonstrated when soaking the bones in water, which becomes greasy. This greasiness as well as the thinness of salmonid head bones was observed in this burning experiment. A larger number of the preserved bones were vertebrae, even though both of my fish specimens were quite big. The whitefish head bones survived a little better than the head bones of the trout.

Second burning

After the first burning, I burned all the identified bones again in order to see what would happen to bones at the bottom of a hearth that was used over and over again. I threw the bones in the bottom of the grill when grilling sausages on the beach. Table 2 lists the bone remains following the second burning.

After the second burning, the bones were a little more fragmented. Most of the pike bones left were still identifiable. The pike bones that were destroyed were mainly those of smaller individuals. Also, the head bones of the small perches, roaches and ides decreased in number. A surprisingly large number of the perch bones left, namely 75%, consisted of vertebrae.

The minimum number of identified roaches and ides also decreased. Only five roaches were found after the second burning, and one of the three ides also disappeared. The result was seven fish individuals. As there were eight smaller (and therefore not bream) first Weberian vertebrae left after the second burning, the total number of individual roaches and ides were estimated to be eight. Most of the whitefish and trout head bones were gone after the second burning. Mostly only vertebrae were left and were well preserved after this second burning. Figs. 1 and 2 show the total number of fragments and vertebrae left, respectively, after the first and second burnings.

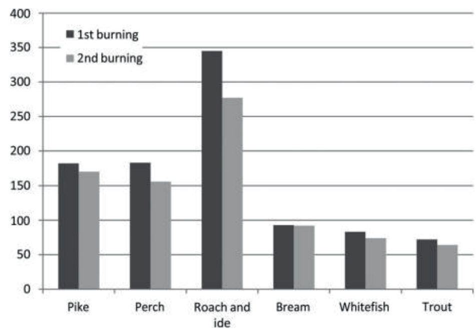

Figure 1 Number of fragments after the first and second burnings.

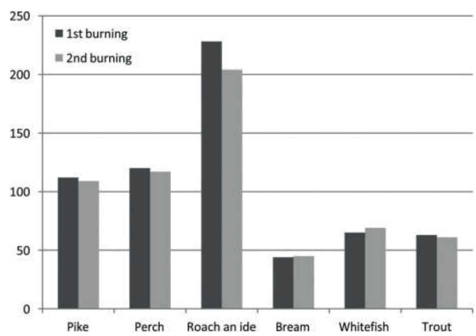

Figure 2 Number of vertebrae after the first and second burnings.

Conclusions

This experiment shows that when fish bones are burned in the open fire, most of the bone loss already takes place in the initial burning. There is no big difference between burning the bones once or twice.

The bones of the bigger pike, perch and bream survived better than the bones of smaller fish. The bones of smaller fish bones were lost in both burnings, but not significantly more in the second burning. The first burning reduced the minimum number of individuals of perch and the second burning reduced that of smaller cyprinids (roach and ide). Smaller bones seem to be destroyed more easily than bigger ones. Fatty whitefish and trout head bones were destroyed almost totally after the two burnings. Nevertheless, a large number of vertebrae of these fish survived.

These results of this experiment correspond to the fish remains found (Nurminen 2006, forthcoming) at Finnish Stone Age sites. Trout was included in this experiment for the sake of comparison because of the discussion concerning the lack of other salmonid fish besides whitefish in Finnish Stone Age fish remains (Nurminen 2006, forthcoming). The vertebrae of both whitefish and trout survived equally well in this experiment. The lack of salmon and trout in Finnish Stone. Age faunal remains could mean that fishing was practised more frequently in lakes than at the seashore.

A specifically interesting question raised by this experiment concerns pike. Pike was well preserved in the burnings and included both head bones and vertebrae. In Finnish Stone Age fish remains, however, pike vertebrae are quite rare, even though pike head bones are found in large numbers in sites throughout the country (Nurminen 2006, forthcoming). What happened to the pike vertebrae? Pikes may have been treated differently than other fish. Pike carcasses could have been dried and stored, and only the heads cut off and thrown into the fire. Perhaps the dried body parts were eaten later without a fireplace. The possibility of trade is unlikely. Finland is, and already was in the Stone Age, full of lakes that were plentiful with pikes easy for anyone to catch. There is also the possibility that pike vertebrae were used for some other purpose, like toys or beads. But why only pike vertebrae? What about other fish species?

This experiment was performed outdoors in order to imitate actual Stone Age conditions. The same experiment could be copied later in a laboratory under more controlled conditions. Then more information could be collected on fire temperature and bone survival rates for lightly burned, blackened and calcined bones.

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FISH BONES AND FISHING IN FINLAND DURING THE STONE AGE

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Doctoral dissertation, to be presented for public discussion with the permission of the Faculty of Arts of the University of Helsinki, in Festive Hall (Juhlasali), Language Centre (Kielikeskus), Fabianinkatu 26, on Saturday, the 16th of January, 2021 at 10 o'clock.

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